ENVIRONMENTAL EVALUATION SYSTEM
for
WATER RESOURCE PLANNING

to

BUREAU OF RECLAMATION
U.S. DEPARTMENT OF THE INTERIOR

January 1972

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FINAL REPORT

on

ENVIRONMENTAL EVALUATION SYSTEM FOR WATER RESOURCE PLANNING

to

BUREAU OF RECLAMATION
U. S. DEPARTMENT OF THE INTERIOR

January 31, 1972

Contract No. 14-06-D-7182

by

Norbert Dee, Janet K. Baker, Neil L. Drobny,
Kenneth M. Duke, and David C. Fahringer

Contributors

Duane E. Bell, Howard Reiquam, John T. McGinnis,
and Ira L. Whitman

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Telex 24-5454

January 31, 1972

Ellis L. Armstrong, Commissioner
Bureau of Reclamation
U.S. Department of the Interior
Washington, D.C. 20240

Dear Commissioner Armstrong:

Battelle's Columbus Laboratories is pleased to submit our final report on an "Environmental Evaluation System for Water Resource Planning". This report is the result of research performed by Battelle-Columbus under Contract Number 14-06-D-7182.

This report summarizes in detail the content and structure of our Environmental Evaluation System for evaluating the environmental impacts of Bureau of Reclamation projects. As such, the report outlines research conducted under our previous contract (Contract Number 14-06-D-7005) to develop the system and under our present contract to field test and refine the system using the Bear River Project as a case study. The report also contains our recommendations for implementation of the system by the Bureau of Reclamation and suggests areas in which further refinements of the system would be desirable.

The Environmental Evaluation System described in the attached report represents a significant advance in the state of the art for incorporating ecological and environmental factors into the planning and evaluation of water resource development projects. The system is a synthesis of the state-of-the-art knowledge, technical skill, interdisciplinary approach, and contemporary values into a comprehensive and systematic tool for evaluating environmental impacts of water resource development. The system incorporates advanced concepts for measuring the environmental consequences of water resource development.

Battelle-Columbus appreciated the opportunity to assist the Bureau of Reclamation in the development and testing of a methodology to enhance and protect the environment, and we would welcome further opportunities to assist the Bureau in other aspects of its environmental planning activities.

Sincerely yours,

Norbert Dee

Norbert Dee
Project Leader

ND/bac
Enclosure(300)

EXECUTIVE SUMMARY

In response to provisions of the National Environmental Policy Act of 1969, the Bureau of Reclamation contracted with Battelle-Columbus to develop an Environmental Evaluation System (EES) for assessing environmental impacts of water resource development projects proposed by the Bureau. This work was conducted in two phases. The first phase involved the development of the EES and the second phase involved field testing and refinement of the EES using the Bear River Project in Utah, Idaho, and Wyoming as a case study. This report summarizes the results of both phases of this work.

The EES developed by Battelle-Columbus is based upon a hierarchical arrangement of environmental quality indicators – an arrangement that classifies the major areas of environmental concern into major categories, components, and ultimately into parameters and measurements of environmental quality. The EES provides for environmental impact evaluations in four major categories: ecology, environmental pollution, esthetics, and human interest. These four categories are further broken down into 18 components and finally into 78 parameters.

In response to requirements established by the Bureau of Reclamation, the approach used in developing the EES was comprehensive, systematic, and interdisciplinary. The research team that participated in the development of the EES was comprised of individuals representing the following disciplines: civil engineering, water resources management, sociology, ecology, and landscape architecture.

The EES described in this report provides a means for measuring or estimating selected environmental impacts of Bureau projects in commensurate units termed Environmental Impact Units. Results of using the EES include a total score in Environmental Impact Units "with" and "without" the proposed project; the difference between the two scores is one measure of environmental impact. Environmental impact scores developed in the EES are based upon the magnitude of specific environmental impacts and their relative importance as judged by the interdisciplinary team conducting the research.

The categories and components developed for the EES for Bureau of Reclamation project evaluations are:

- (240) Ecology
  - (140) Species and Populations
  - (100) Habitats and Communities
- (402) Environmental Pollution
  - (318) Water Pollution
  - (52) Air Pollution

- * Ecosystems

(153) Esthetics
- (32) Land
- (5) Air
- (52) Water
- (24) Biota
- (10) Man-made Objects
- (30) Composition
- (28) Land Pollution
- (4) Noise Pollution

(205) Human Interest
- (48) Educational/Scientific Packages
- (55) Historical Packages
- (28) Cultures
- (37) Mood/Atmosphere
- (37) Life Patterns

The relative importance of the parameters expressed in Parameter Importance Units (PIU) are grouped by category and component in the above parentheses. A total of 1,000 PIU are distributed to the 78 parameters in the EES.

Another major output from the EES is an indication of major adverse impacts, "red flags", which are of concern of and by themselves. These flags indicate to the Bureau "fragile" elements of the environment which must be studied in more detail.

The EES as described in this report is ready for use by the Bureau of Reclamation in both its project planning and evaluation activities. Suggested areas in which further refinements of the EES would be desirable are also outlined in this report.

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* Descriptive Only.

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ENVIRONMENTAL EVALUATION SYSTEM FOR WATER RESOURCE PLANNING

by

Norbert Dee, Janet K. Baker, Neil L. Drobny,
Kenneth M. Duke, and David C. Fahringer*

EXPLANATION OF THE ENVIRONMENTAL EVALUATION SYSTEM

INTRODUCTION

Battelle-Columbus developed for the Bureau of Reclamation a method of quantifying in an Environmental Evaluation System (EES) environmental impacts of water resource development projects with respect to ecology, environmental pollution, esthetics, and human interest. Measures of impacts in each of these categories are expressed in Environmental Impact Units (EIU) to allow for explicit tradeoffs between beneficial and adverse environmental changes. The EES also provides an alerting system that identifies particularly environmentally sensitive areas of a proposed project. In addition to providing information on environmental impacts of specific project proposals, the EES can be used in the planning phase to identify project designs that meet most development objectives while minimizing adverse environmental impacts.

Objective

The purpose of the research conducted by Battelle-Columbus was to develop an operational Environmental Evaluation System (EES). The research consisted of field testing the EES, conceptually developed under an earlier contract (Contract Number 14-06-D-7005), and then using the results to reevaluate and modify the EES as appropriate. The EES developed by this procedure can be directly implemented in either the planning or the evaluation phases of Bureau project activities.

---

* Fahringer, McCarty, Grey, Inc., Landscape Architects and Engineers, Monroeville, Pennsylvania.

Scope

The Environmental Evaluation System was field tested on the Bear River Project in Utah, Idaho, and Wyoming. This project was selected by the Bureau because of its similarity to other Bureau projects and because it possessed the degree of complexity needed to test the system. In conducting the field test, the ecological, environmental pollution, esthetic, and human interest impacts of selected features of the Bear River Project were analyzed.

The approach used in the field testing and improvement of the EES was comprehensive, systematic, and interdisciplinary:

- Comprehensive, because the environment is an intricate system of living and nonliving elements held together in a delicate balance and because environmental concerns relating to large scale projects range widely from impacts on natural resources – air, water, land – to impacts on living organisms – plants, animals, microorganisms – to a variety of impacts on people – esthetic, cultural, and emotional.
- Systematic, because to be effective as a decision making or planning tool, environmental impact assessments must be replicable by different analysts and must be able to withstand scrutiny by various interest groups.
- Interdisciplinary, because environmental concerns which are related to resources, living organisms, and people obviously require a broad range of talents and disciplines for analysis – including at a minimum the physical, biological, and social sciences.

The method of field testing the system and making desired improvements was systematic in nature and replicable. The resulting EES is reasonably applicable to any Bureau project, and the evaluation can be approximately replicated by different analysts. The development, test, and refinement of the EES was performed by an interdisciplinary team of ecologists, environmental planners, engineers, landscape architects, and social scientists.

Description of Research

These studies were conducted by a research team consisting of five members. Although members of the research team contributed to the study in their respective areas of expertise, development and testing of the EES was a joint effort. In addition to the five-member core team, other specialists also participated in the research.

The following general tasks were performed by the research team:

(1) Planning and organization of the field study

(2) Performance of field study

(3) Reevaluation and redevelopment of procedures for evaluating impacts

(4) Definition of research needs.

Selected State-of-the-Art Review

A variety of techniques have been proposed for evaluating tangible and intangible aspects of environmental quality. Each of these was reviewed by the research team in the early stages of formulating the EES, and selected factors of some proposed systems are reflected in the EES and in the recommendations for its future development. A brief review of some of these approaches may be useful to readers interested in pursuing in detail the subject of quantitative, comprehensive environmental analysis.

Orlob, et al.,(1) proposed two methods for evaluating monetary and nonmonetary aspects of Wild River preservation and development. The work is based on the premise that all evaluations must ultimately be reduced to a benefit/cost ratio because this indicator has become so ingrained in our decision making processes. Two arbitrary criteria are proposed for expressing nonmonetary benefits in dollar forms:

- Nonmonetary benefits associated with the wild, least-developed condition of a river are at least equal to the foregone monetary benefits that would accrue if the basin were developed to its fullest.
- Nonmonetary benefits equal between 0.25-2.0 times the monetary benefits.

Each of these assumptions makes the calculation of nonmonetary benefits very convenient and straightforward, but really has no rational basis. Further, in calculating the benefit/cost ratio, only monetary costs are included; no provision is made to include nonmonetary costs of development such as various adverse impacts on ecology, lost park areas, etc.

Leopold, et al.,(2) proposed a matrix system for use in assessing environmental impacts; however, the system is more of an inventory or cataloging system than an overall evaluation system. One dimension of the matrix contains 100 types of actions that can result in environmental impact and the other dimension is a list of 88 environmental characteristics that can receive environmental impacts. This results in a matrix with 8,800 cells. Each cell is filled with two numerical indicators. First, on a scale from 1-10, the evaluator indicates the magnitude of the impact in question with minus or plus used to signify adverse or beneficial impacts respectively. Next, on the scale from 1-10, the evaluator indicates the relative importance of each impact. The system suffers from two main limitations. First, it is extremely difficult to assess overall impact by inspection of as many as 17,600 matrix entries. Secondly, the evaluator is allowed the freedom of selecting relative weights; this feature opens the door for the evaluator's bias to enter the evaluation, thereby leading to nonobjective evaluations.

Another system developed by the Bureau of Reclamation in conjunction with the Western U. S. Water Plan combines certain features of the Leopold and the EES system.(3) It is similar to the Leopold system in that it provides no means for overall aggregated environmental evaluations. Evaluations are provided in three main dimensions of resource measurement: quantity, quality, and human influence. However, no means is provided for assessing trade-offs among these three dimensions. The approach is similar to the EES in that many of the parameters, especially in the human influence area, are similar to those in the human interest area of the EES. No attempt is made to discriminate relative importance of parameters in the three environmental dimensions, suggesting that this is left up to the evaluator's judgment.

Dearinger(4) has proposed a rating and weighting system for assessing the esthetic and recreational potential of small streams and urban areas. The proposed approach is highly use oriented and considerably limited in scope.

An approach to the evaluation of natural rivers developed at Antioch College is one of the most comprehensive evaluation systems identified by the research team.(5) It addresses geologic, hydrologic, cultural (historic and esthetic), and vegetative characteristics of the environment. Two limitations noted are that the importance of fauna is not treated explicitly and all parameters are treated with equal weight. The existing structure of the parameter list does not justify each being treated with equal weight.

Odom(6) has developed a system for assessing environmental impacts of highways similar in basic structure to the EES. Impact is indicated as a linear combination of weighted component values. A total of 56 highly nonhomogeneous components are employed. Unfortunately, components are a mixture of cost considerations along with environmental considerations. For example, benefit/cost ratio is one of the parameters; its contribution to overall impact is calculated by multiplying benefit/cost ratio by a relative weight of -10. Thus, even the most favorable benefit/cost ratio contributes a negative impact to environmental quality. Several inadequacies of this type detract from the utility of the system.

Turning to more narrow approaches to evaluating environmental quality, specifically air and water quality, several approaches to developing air quality indices and water quality indices are reported in the literature. Many of these approaches provide the basis for the development of the EES.

The above review is by no means a comprehensive state-of-the-art review. The approaches mentioned, however, are typical of the variety of evaluation systems being proposed by various researchers for various purposes in response to requirements of the National Environmental Policy Act. As indicated, considerable effort was invested in reviewing the elements of these systems for possible incorporation into the EES.

DESCRIPTION OF THE ENVIRONMENTAL EVALUATION SYSTEM (EES)

The environment is a complex system consisting of physical, biological, and social resources. Use of these resources by man can have both a beneficial and an adverse impact on the environment. Evaluation of these impacts is an important but often difficult task.

The Environmental Evaluation System (EES) was designed for use in evaluating the environmental impacts of the Bureau of Reclamation's water resource developments. The system is hierarchical in nature, measures environmental impacts in commensurate units, and alerts the Bureau to environmentally sensitive areas.

Hierarchical System

The structure of the EES is hierarchical in nature to account for the different levels of information used in the impact analysis. Four levels of information are used in the EES:

Level 1 – Most general information–ENVIRONMENTAL CATEGORIES
Level 2 – Intermediate information–ENVIRONMENTAL COMPONENTS
Level 3 – Specific information–ENVIRONMENTAL PARAMETERS
Level 4 – Most specific information–ENVIRONMENTAL MEASUREMENTS.

These four levels of information are related schematically as shown in Figure 1.

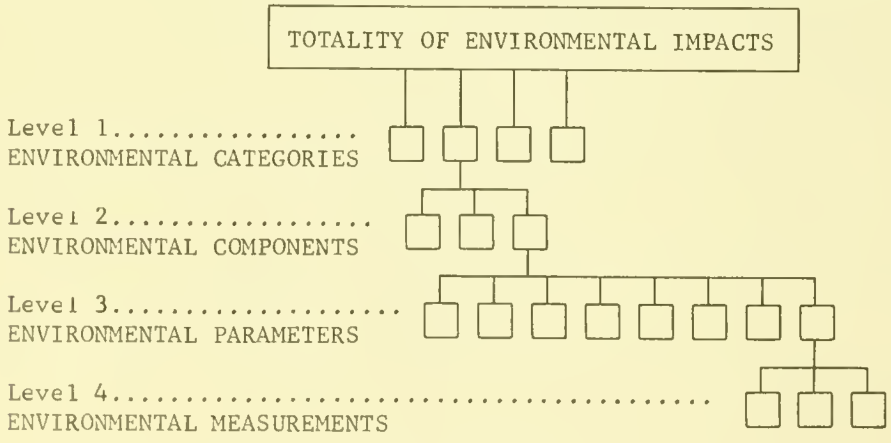
TOTALITY OF ENVIRONMENTAL IMPACTS
Level 1..................
ENVIRONMENTAL CATEGORIES
Level 2..................
ENVIRONMENTAL COMPONENTS
Level 3....................
ENVIRONMENTAL PARAMETERS
Level 4..
ENVIRONMENTAL MEASUREMENTS

FIGURE 1. HIERARCHICAL STRUCTURE OF THE EES

Level 3 is the key level of environmental impact within the EES. Each environmental parameter represents a unit or an aspect of environmental significance worthy of separate consideration. In selecting parameters for inclusion in the EES it was decided that

- Parameters should be highly comprehensive indicators of environmental quality.
- Parameters should be easily measurable in the field.
- Parameters should be relevant to Bureau of Reclamation activities.
- Parameters should be capable of being measured on a project scale.
- The total list of parameters should be as compact as possible.

Use of these screening criteria helped strike an important balance between too little and too much detail.

Groups of similar parameters in the EES are defined as environmental components. Each of these components represents terms of intermediate generality. The major classification, environmental categories, is the grouping of components into similar areas.

The environmental measurements constitute the data needed to obtain a representative parameter estimate. These data may be obtained from historical records or from several different measurements that are functionally related to obtain the desired estimate. The transformation of these data into a parameter estimate cannot be prescribed in detail because it is dependent on the parameter considered and the project area investigated. Therefore, the selection and use of the measurement data to obtain a parameter estimate based on the professional judgment of the evaluator.

Impacts Expressed in Commensurate Units

Water resource developments may create both beneficial and adverse impacts on the environment. Because properties of the environment are not commonly measured in commensurate units, it is difficult to evaluate the net environmental effects of a Bureau project. To solve this trade-off problem, Battelle-Columbus developed a technique to transform all parameters into commensurate units. This technique consists of three steps:

Step 1	Transform all parameter estimates into their corresponding environmental quality
Step 2	Weight all parameters in proportion to their relative importance
Step 3	Multiply the environmental quality of the parameters by their relative weights to obtain the common units.

Step 1. Environmental Quality

At the present time, analyses of water resource projects with respect to their impact on environmental quality is based almost entirely on standards for physical/chemical aspects of the environment. In many cases these standards are represented as the upper limits or maximum ranges as measured by selected parameters that will be acceptable to maintain the desired "quality".

The use of standards is important in administering and enforcing a desired policy, but it is possible to improve on this approach for the planning and evaluation of the environment. Essentially, environmental quality is not confined to a bad or good scale, but includes a range of values between these two extremes.

In the EES, environmental quality is defined in this fashion. It is a value between 0 and 1, where 0 denotes extremely bad quality and 1 is very good quality. By defining environmental quality in this way, it is possible to account for any changes that improve quality and are, therefore, beneficial impacts on the environment. It is also possible to account for marginal deterioration of the environment without waiting until the standard is reached or exceeded.

An additional benefit of this approach is the resulting common base. Because all parameters are related to environmental quality between 0 and 1, it is possible to compare different parameters on a common base. This transformation of parameters into a common range is necessary to be able to express environmental impacts in commensurate units.

The transformation of a parameter estimate into environmental quality is achieved through the use of a value function which relates the various levels of parameter estimates to the appropriate levels of environmental quality. An example of a value function is given in Figure 2.

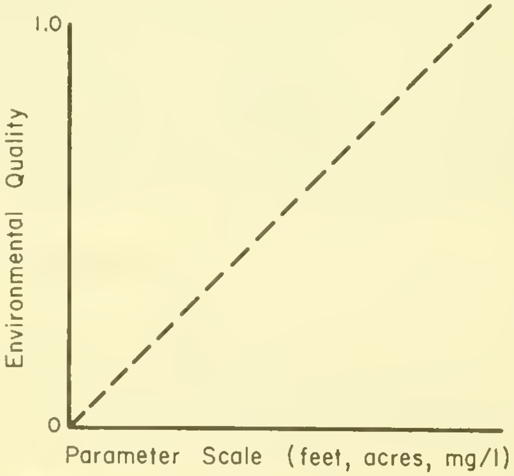

FIGURE 2. TYPICAL VALUE FUNCTION

The parameter estimate used in the value function is a representative value which is obtained from environmental measurement data, Level 4 of the EES.

Step 2. Parameter Weights

Each of the parameters used in the EES represents only a part of the total environment. It is, therefore, important to view these parts together as part of the environmental system. In doing so, however, it must be recognized that some parameters are more important than others. Parameters of "lower" importance can not be discarded because they are still part of the overall system.

To reflect the relative importance of the parameters as indicators of the degree to which the Bureau of Reclamation projects may disturb or enhance the dynamic stability of man's relationship with the natural and social environment, all parameters were assigned relative weights. These weights are expressed in Parameter Importance Units (PIU) and are based on a total of 1,000 PIU.

Because the weights developed for the EES represent relative importance within the overall system, they should not vary from project to project. This will allow all individuals using the EES to be relatively consistent in their evaluation of the environment. If, on the other hand, weights were allowed to vary from project to project, the assignment of weights would be the responsibility of the investigating team. Essentially, each team would have their own "special" weights depending on their views and background which would produce results that would be extremely difficult to replicate. (An analogy in the benefit/cost ratio of economics would be to allow the value of the dollar to vary with the nature of the benefit or cost being considered.) Furthermore, by keeping the weights constant, the Bureau can minimize the emotion generated during a project analysis, and therefore be objective in its evaluation of alternatives.

Step 3 Obtain Commensurate Units

In Step 1 each set of parameter measurements was related to an environmental quality scale between 0 and 1, and in Step 2 each parameter was assigned its relative importance. The results of both of these steps are combined in Equation 1 to obtain the desired commensurate units for environmental impact trade-offs.

$$\underset{(\text{EIU})}{\text{Environmental Impact}} = \underset{(\text{PIU})}{\text{Parameter Importance}} \times \underset{(\text{EQ})}{\text{Environmental Quality}}. \qquad (1)$$

In the EES, environmental impacts are measured in Environmental Impact Units (EIU) which are a function of Parameter Importance Units (PIU) and Environmental

Quality (EQ). The resulting EIU can be used to trade-off beneficial environmental impacts with adverse environmental impacts.

The EES can be used in two ways: (1) to measure the environmental impact of alternative water resource developments, and (2) to plan future developments with minimal adverse environmental impacts. These two uses indicate the short and long term importance of environmental analysis. Once the EES can become part of the planning process, it can be used effectively to "improve" the environment in some areas and protect it in others.

The EES is used by evaluating with Equation 1 the expected future environment "without" the project and then "with" the project. The former evaluation is an expression of the modified current condition of the environment while the latter is an expected (predicted) condition of the environment with the development. A difference in Environmental Impacts Units between these two conditions constitutes either an adverse (loss in EIU) or a beneficial (gain in EIU) impact.

Warning System

It is important for the Bureau of Reclamation to know if any "fragile" elements of the environment would be disturbed by a project development. Unfortunately these "fragile" elements change from project to project and there is no special formula to identify them in general. Thus, each parameter in the EES must be considered a potential "fragile" element that could, for some project, be crucial in determining the magnitude and significance of the overall environmental impact.

The approach used to identify these potential problem areas is to key out parameters with "red flags" that change significantly in the adverse direction. These "red flags" are measured by differences in the environmental quality of a parameter "with" and "without" a proposed project; recall that the value function is used to obtain environmental quality between 0 and 1.

In the calculation of "red flags" all parameters are given equal importance. To differentiate between the magnitude of the potential problem, both a minor and a major "red flag" are used.

It must be reemphasized that a "red flag" is only a warning, not an absolute definition of a problem. After a "red flag" is identified, the Bureau must investigate the potential problem area in detail to determine whether or not a problem exists.

Another use of "red flags" is to signal parameters for which there are either no data or only qualitative data. Effort must be made by the Bureau to fill these data gaps.

CONTENT OF THE ENVIRONMENTAL EVALUATION SYSTEM

Water resource development in the context of Bureau of Reclamation activities has impacts on both the physical and social environments. For this reason, "Environment" as used in the EES was defined to include the four categories of Ecology, Environmental Pollution, Esthetics, and Human Interest. It is further divided into 18 components* and 78 parameters which are shown in Figure 3, a fold-out located for convenience in the front of this report. The numbers appearing on the fold-out refer to the relative importance of each parameter in the EES as measured in PIU. Because both the components and the categories perform a grouping function, the sum of each grouping in PIU appears in the appropriate location.

The weights used in the EES relate to the parameters and, therefore, it is possible to compare parameter importance by using their PIU. However, to compare the importance of the categories and the components it is necessary to use average Parameter Importance Units per grouping instead of total units because of the different number of parameters in each category and component. (See the next section on weighting procedure for a further discussion.)

Certain parameters listed in the EES seem to be similar in nature like Turbidity (Water Pollution) and Appearance of Water (Water, Esthetics), but they do not constitute duplicate measurement of environmental impact. Each category is used to evaluate the parameters differently, using different criteria. It was easier from an organization viewpoint to list both parameters than to list one and define all possible interactions.

Each of the four levels of the EES are described in detail below, along with a discussion on the value functions associated with each parameter.

Ecology

Balanced natural systems that are characterized by orderly interconnections among their various components are stable, healthy, and productive. Man is a part of natural systems and whether or not the natural systems are balanced often depends on his actions. Man's ability to dominate the environment has grown as a direct result of burgeoning population and technology. However, his understanding of how this balance operates or how critical the future supply of the resources is to his existence, has not kept pace. As a result, man has frequently disturbed this balance, reducing the stability, the productivity, and the ability of the system to regenerate renewable and to supply nonrenewable resources.

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*Although there are 18 components, only 17 are used in the quantifiable aspects of the EES.

Ecology measures changes in natural systems by estimating the impacts upon the biota and the habitats in which they live. The Bureau's water resource projects can have significant impact upon the aquatic habitats and biota by regulating waterflow and creating impoundments. Possible effects on the terrestrial environment include increased water for farms, municipalities, and industries; inundation of land; alteration of land through construction of dams and other structures; and many others.

Ecology is concerned with all the organisms living in a habitat, the physical and chemical characteristics of that habitat, and the processes which unite these two categories into a functioning system. It is a young science less than 100 years old and has not yet acquired the huge body of data about the environment nor reached the level of sophistication in data analysis that older sciences have. Ecologists do have considerable data on many species and habitats, but they lack a detailed understanding of the processes which connect species and habitats together into stable, productive ecosystems. There is also a lack of understanding of man's part in the environment, and of what his role must be if he is not to destroy the environment and be destroyed himself as a result. This lack of complete knowledge about the functioning of the ecosystem is reflected by the fact that few good measures of ecosystems currently exist, and those available are best used as modifiers of other parameters describing species or habitats.

Because it is desirable to implement the EES without further delay, it was necessary to use parameters for which reliable data could be obtained with existing techniques and within a reasonable amount of time and cost. Theoretical parameters for which data were lacking or were very difficult to obtain and interpret were, therefore, of little use in the EES.

Eighteen ecological parameters were selected which, in general, could be measured and could provide a means for (1) describing the state of the balanced natural system, (2) indicating the current conditions and trends of similar parameters, (3) measuring environmental quality in reference to man and his use of the environment, and (4) identifying sensitive areas such as habitats or species of sport, commercial, or educational interest.

Since there are only 18 parameters with which the ecology of the proposed project site can be described and evaluated in the EES, each parameter must convey an accurate description of the status of a large portion of the ecosystem or ecosystems affected by the project. A single measurement, such as density, area, or productivity, often cannot give this accurate description. Thus, for the EES, more than one measurement will be used to estimate the values for many of the ecological parameters. This approach requires identifying two or more measures which can be used together in such a manner as to give a single number. This number, used in conjunction with the value function, will convey an accurate description of that portion of the ecosystem to be described by the parameter. The measures are multiplied to give the parameter estimate.

$$\text{Parameter Estimate} = \text{Magnitude} \times \text{Quality Modifier(s)} .$$

The magnitude will usually be a measure of the total area of a particular ecological habitat available within the project boundaries. This magnitude is multiplied by one or more measures of the quality of that magnitude measure. Quality measures may be density, productivity, or some other similar measure. In order to keep the parameter estimate on a reasonable scale and sensitive to change, all the measures of quality are normalized on a 0 to 1 scale. The process of normalization consists of determining for the specific habitat the maximum and minimum values for the quality modifier. These are assigned a value of 1 and 0 respectively. The actual value of the quality measure is then expressed as a proportion of the maximum value. Unless the minimum value for the quality measure is actually 0, interpolation is necessary to give the correct proportion. For example, if the maximum and minimum possible quality values are 50 and 0 for a given habitat, a measured quality value of 20 would have a proportional value of 0.40 $\left(\frac{20}{50}\right)$ on the normalized scale. However, if the maximum and minimum possible values are 50 and 10 respectively, the measured quality value of 20 would be 0.25 $\left(\frac{20 - 10}{50 - 10}\right)$ on the normalized scale. The magnitude times the normalized quality value or values gives the parameter estimate. A few parameters do not use this technique and require only a single measurement to estimate the parameter value.

The setting of appropriate boundaries for each Bureau project is important because the area selected often determines the parameter's magnitude. Although there are impacts on the environment at the site of the dam and the impoundment, there are also impacts wherever the water or hydroelectric power from the site is transported and used – often many miles distant. Furthermore, many of the animals (fish, livestock, big game, birds of prey, waterfowl, and others) make daily and seasonal movements of considerable distances; destruction of a valuable winter range may influence a deer herd spending the summer 15 to 20 miles away. Thus, ecological boundaries for a project must be large to be certain of including all those species and habitats that may be influenced. Often, that area of the drainage basin within the counties receiving water or other benefits from the project coincides with the area receiving significant ecological impact from the project.

Species and Population

Ecology is a hierarchical science with species and populations defined as the lowest level. Because past and many present ecological analyses are concerned with this level, information about species and populations is often excellent. Species included in the EES are those which are either good indicators of a healthy environment or of commercial, recreational, or economic value to man or both. This level is quite sensitive and can be used to detect subtle changes which may, in time, result in major impacts upon the health of the environment. Because of the nature of Bureau projects, the measure used for most of the parameters is that of area. These projects inundate land, change terrestrial acreage to aquatic acreage, irrigate large areas of dry land, and often supply municipal and industrial water to provide for the growth of industry and the human population, both of which usually require large acreages. Due to the great sensitivity to change of species and populations, the productivity rates formerly measured at the ecosystem level are included at this level as descriptors of the quality of the area measurement.

Browsers and Grazers (Terrestrial). Large browsers and grazers, which include cattle, horses, sheep, and other livestock as well as deer, elk, and other large, wild herbivores, are the dominant animals of many terrestrial ecosystems in the western states. Any change in their numbers or in the ability of the land to support the populations may result in a significant impact upon the health and stability of the environment. Because these dominant species are either domestic animals supplying food and other products of value to man or are desirable game animals offering recreation and food, the importance of predicting their change is increased. This importance often means that reasonably good data on their abundance and on the ability of the land to support them will be available throughout the western states.

Ultimate capacity is used in evaluating the magnitude of the impact of any predicted change in these populations. The ultimate capacity of the land within the project boundaries defines the number of grazers that could be supported if they consumed all the net annual plant production. However, in actual practice only 50 to 60 percent of the net annual, above-ground production of the plants can safely be consumed. The remaining 40 to 50 percent provides (1) food storage for perennial plants for their continued growth and survival, (2) the source of plants to replace those lost to herbivores, disease, and to other means, and (3) the supply of most of the organic input to the detrital portion of the ecosystem which is important in nutrient regeneration. Thus, 40 to 50 percent of the annual plant production must remain in the ecosystem if that system is to be self-renewing.

This leads to the value function shown in Figure 4. Maximum environmental quality (EQ) is attained at 50 to 60 percent of the ultimate capacity of the land within the project boundaries. When this range is exceeded, the stability of the system is disturbed and the EQ drops rapidly to zero. At values less than the optimum, the value function also declines, indicating that the full potential of the system is not being utilized.

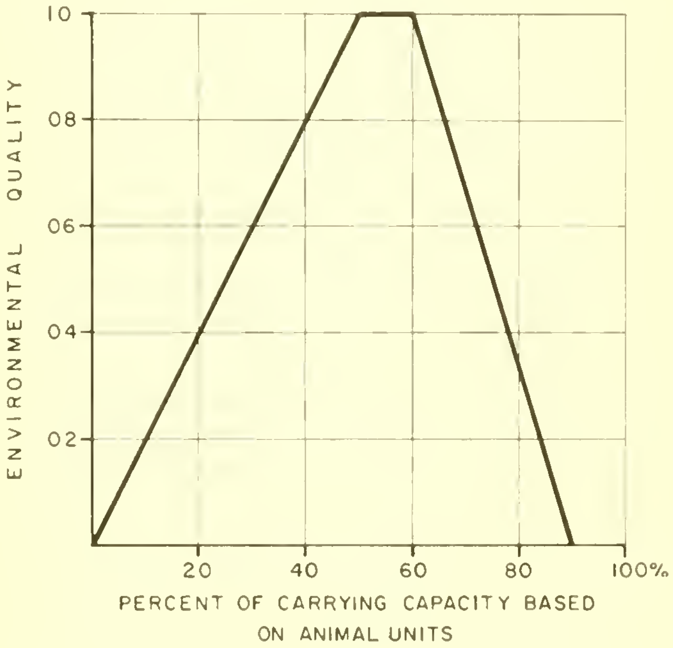


FIGURE 4. BROWSERS AND GRAZERS

To use the value function, it is necessary to determine the ultimate capacity of the land both "with" and "without" the project. First, the number of browsers and grazers, by species, occurring within the boundaries "without" the project is obtained. These data are then converted to Animal Units (AU), a standard agricultural measure based on the food consumption of a cow (9,600 lb per yr).

Next, the net annual production in pounds per acre is determined for each of the various kinds of habitats where grazing and browsing does or might occur (irrigated farmland, gazed arable land, natural vegetation, etc.). Dividing the annual AU food requirements in lb per year, by the net annual plant production, in lb per acre per year, for each habitat type gives the number of acres of each habitat type needed to support one AU:

$$\frac{\text{Acres of Habitat}}{\text{AU}} = \frac{\text{AU}}{\text{Net Plant Production}} , \tag{2}$$

where

AU = lb/year

Net Plant Production = lb/acre/year.

Finally, dividing the number of acres of each habitat type ("without" the project) by the number of acres required to support one AU gives the ultimate capacity in AU for each habitat. Summing the carrying capacities for the several habitats gives the ultimate capacity for the total project area and is the number equated with 100 percent on the value function:

$$\text{Ultimate Capacity} = \sum_{1}^{N} \left[\frac{(\text{Acres of Habitat Type})}{\text{Acres of Habitat/AU}}\right] , \tag{3}$$

where

N = Number of Habitat types.

Dividing the total AU occurring in the project area by the ultimate capacity and multiplying by 100 gives the percent of ultimate capacity without the project:

$$\text{Parameter Estimate} = \frac{\text{Total AU}}{\text{Ultimate Capacity}} \times 100 . \tag{4}$$

Repeating this operation, using any changes in area, annual production, and number of AU caused by the construction and operation of the project, gives the ultimate capacity, the number of AU, and finally the percent of ultimate capacity these AU comprise "with" the project.

Crops (Terrestrial). Crops, including both grain and forage, occupy a large part of the arable land in the western states. Many of the Bureau of Reclamation's projects are concerned with supplying irrigation water to these lands. Consequently, these projects do have an impact upon the environment. Because moisture is often the limiting factor for crops in the western states, the impact of increased irrigation water upon crop productivity is usually beneficial. Good data on both the area covered by the various types of farming (irrigated, dry, grazed) and the productivity of these areas are generally available and facilitate the evaluation of this parameter.

The value function for crops is linear (Figure 5). The horizontal axis is the percent of the total arable land within the project boundaries which is cultivated. The total arable land is defined at 100 percent on the horizontal axis. To obtain the percent "without" or "with" a proposed project, the concept of magnitude modified by a measure of quality for that magnitude is used. The magnitude for crops is the area in acres for each type of farming – irrigated, dry, and grazed. The quality modifier is a weighted estimate of net annual fresh weight production. The modifier is weighted on a 0 to 1 scale as follows:

Modifier Value	Production
1.0	8000 lb/acre/yr
0.75	4000 lb/acre/yr
0.50	2000 lb/acre/yr
0.25	1000 lb/acre/yr
0	0 lb/acre/yr

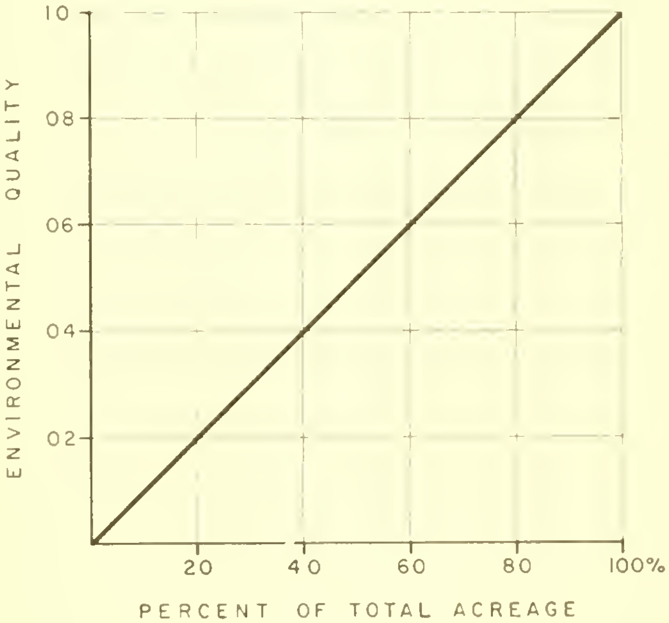


FIGURE 5. CROPS

The net annual production is determined for each farming type and then assigned a modifier value using the above scale. If the production is intermediate between two levels marked on the scale, it is assigned an intermediate value (1500/lb/acre/yr would receive a weight of 0.38). The fractional quality modifier obtained is multiplied by the magnitude, in acres, of the farming type to give a modified acreage. Summing the modified acreages for the farming types, dividing this sum by the total arable acreage ("without" the project), and then multiplying the quotient by 100 gives the weighted percent to use in the value function:

$$\text{Parameter Estimate} = \frac{\sum_{1}^{N} (\text{Acres of Farming Type} \times K)}{\text{Total Arable Land}} \times 100 \ , \qquad (5)$$

where

N = Number of farming types

K = Weighted Productivity.

All predicted changes in acreage and production must be used in evaluating this parameter "with" the project. For any increase in irrigated acreage, there must also be a loss in either dry or grazed acreage or both. Some arable acreage may be inundated and the appropriate loss must be shown in the farming type acreage, but not in the total arable land. This insures that arable land inundated will be evaluated as a negative environmental impact.

Natural Vegetation (Terrestrial). Natural vegetation is an important parameter describing the autotrophic portion of the biological community. That area within the project boundaries which is covered with natural vegetation provides most of the food for the wild animals and much for the domestic grazers using the project area. Any change in that area may (1) reduce the food supply available for wild and domestic animals and (2) disturb the stability of the ecosystem. Disturbing the stability may permit erosion, reduction of the fertility and production of the land, and/or invasion of noxious weeds and other undesirable plants.

A linear value function is used for this parameter (Figure 6). As the percent of the available land covered with natural vegetation increases, the EQ increases. The concept of a magnitude multiplied by a quality modifier is used in this value function. The magnitude is a measurement of area and the qualifier is a weighted estimate of net annual production. To maintain the 100 percent limit, the modifier must be given a 0 to 1 weight.

Net annual production of natural vegetation is weighted exactly the same as for crops. The available area for natural vegetation within the project boundaries is the total amount of nonarable land (exclusive of urban, industrial, and residential land). This area is 100 percent on the value function. To determine the actual values for a site "with" and "without" the project, the area of each type of natural vegetation

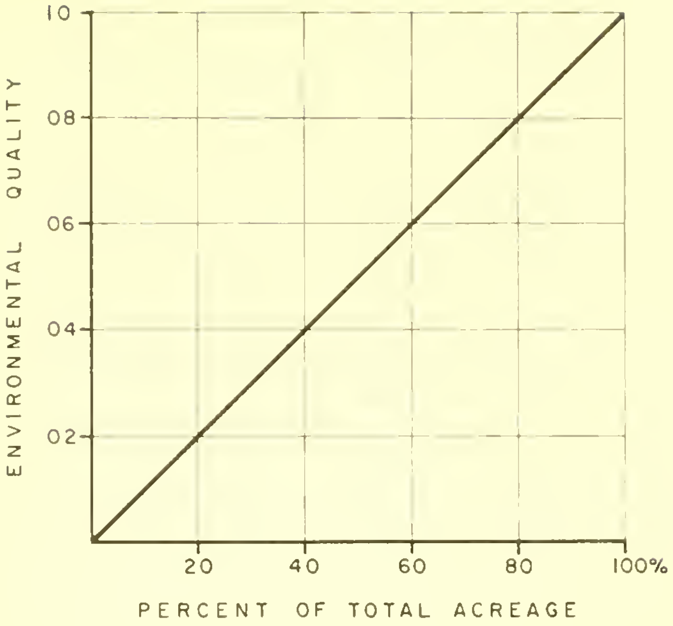


FIGURE 6. NATURAL VEGETATION

habitat is determined as well as the net annual production for that habitat. The net annual production is converted to a fraction using the same 0 to 1 scale given for crops. The fraction obtained is multiplied by the area of the habitat type. Summing these values for all the habitat types gives a weighted acreage which, when divided by the total nonarable acreage, gives the percent value "with" or "without" the project:

$$\text{Parameter Estimate} = \frac{\sum_{1}^{N} (\text{Acres of Vegetation Type x K})}{\text{Total Nonarable Land}} \times 100 \,, \qquad (6)$$

where

N = Number of categories

K = Weighted Productivity.

These values are used in conjunction with the value function to determine the "with" and "without" EQ.

Pest Species (Terrestrial). Terrestrial pest species is a parameter designed to measure any change in the distribution and occurrence of species annoying or harmful to man or his crops, livestock, or game animals. While data on pest species is limited and usually qualitative, it is necessary to make some estimate of the impact of Bureau projects upon these species.

A linear value function is used to describe the change in EQ as the pest species change (Figure 7). Pest species are divided into two areas, those pests that are plants and those that are animals. Under each area two categories are recognized and are allotted a fixed magnitude or weight:

Category	Weight
Plant Species	
(1) Weeds	0.25
(2) Diseases	0.25
Animal Species	
(1) Diseases and carriers	0.25
(2) Pests	0.25

Plant diseases include smuts, rusts, root rots, and many others. Weeds are undesirable or noxious plants. Animal diseases and carriers include all diseases caused or carried by animals. Thus, when a plant disease is transmitted by an animal, the impact of the disease would be evaluated under the plant disease category and the impact of the diseased carrier under animal disease category and carrier. The animal pest category includes any annoying species.

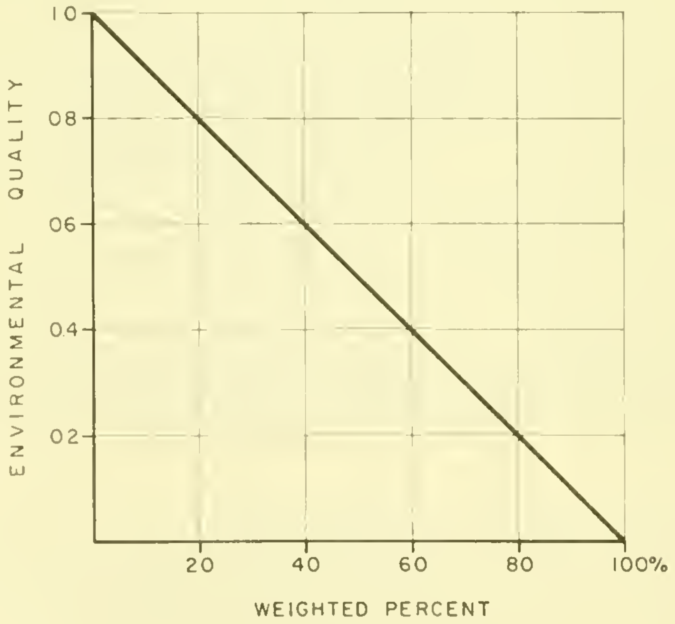


FIGURE 7. PEST SPECIES

The weight of each category is modified by an estimate of distribution of the species:

Distribution	Modifier
Widespread	1.0
Intermediate	0.67
Restricted	0.33
Absent	0

The distribution of the various species of a particular category is estimated using the above scale, and the respective modifier is then multiplied by the weight of the appropriate category. The sum of the products for all the categories is the number used in the value function:

$$\text{Parameter Estimate} = \sum_{1}^{N} (\text{Category Weight} \times K) \times 100 \ , \qquad (7)$$

where

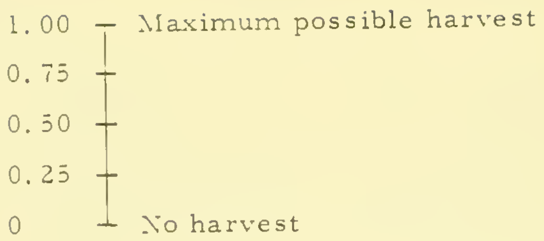
N = Number of categories

K = Distribution modifier.

This technique is used for estimating the EQ both "with" and "without" the project. Change resulting from construction and operation of the project is estimated by knowing the species and their distribution "without" the project and determining the effect the proposed project might have on them.

Upland Game Birds (Terrestrial). Upland game birds are important both as a source of recreation and food for man and as an indicator of the stability and productivity of the habitats they use. While small mammals, arthropods, reptiles, song birds, and others may also live in these same habitats, data on the density and area used are probably best for the upland game birds. This fact, along with their value as game animals, make them an excellent indicator.

Figure 8 shows the value function to be linear. The magnitude measured is the habitat area, and the total available area within the project boundaries is equated with 100 percent. The actual magnitude "with" or "without" the project is the area inhabited, and its quality modifier is the weighted annual harvest of birds. A scale from 0 to 1 is used:



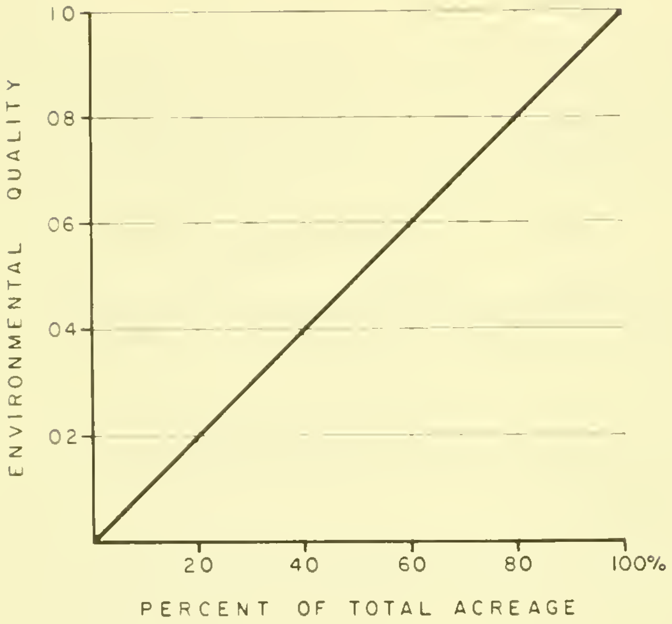


FIGURE 8. UPLAND GAME BIRDS

Using past harvest records, the maximum possible annual harvest can be calculated. These harvests which are reported during the years of record for all the upland game species occurring within the project boundaries are summed to give the total maximum annual harvest. For newly introduced species not yet at their maximum level, an estimate of that level must be made. This number is equated with 1.0 on the modifier scale. The annual harvest for the year nearest the environmental analysis is divided by the maximum, the resulting quotient being the modifier to be multiplied by the actual inhabited area. This product, divided by the total possible habitat is the parameter estimate "without" the project:

$$\text{Parameter Estimate} = \frac{\text{Area Inhabited} \times K}{\text{Maximum Habitat Area}} \times 100 , \qquad (8)$$

where

K = Weighted annual harvest.

Predicted changes in the area inhabited (including habitat inundated) and in the annual harvest caused by the construction and operation of the project are used to determine the parameter value "with" the project.

Commercial Fisheries (Aquatic). Commercial fish can be of great value to man. Many waters of the western states currently harbor or have the potential to support valuable commercial species. The Bureau's proposed projects can significantly affect these existing or potential fisheries. Changes in these fisheries are also indicative of other changes in the environment, and thus the fish may be used as indicator species.

A linear relationship exists between the weighted percent of the area available to commercial fish and the EQ (Figure 9). The magnitude is the area, and the maximum possible commercial fish habitat in surface acres of water within the project boundaries is 100 percent. The actual area inhabited modified by an estimate of quality is the value of the parameter "with" or "without" the project. The quality modifier, because of man's interest, is based on the dollar value of the annual commercial catch. The dollar values are weighted on a 0 to 1 scale:

1.00	$1,000,000
0.67	100,000
0.33	10,000
0	1,000

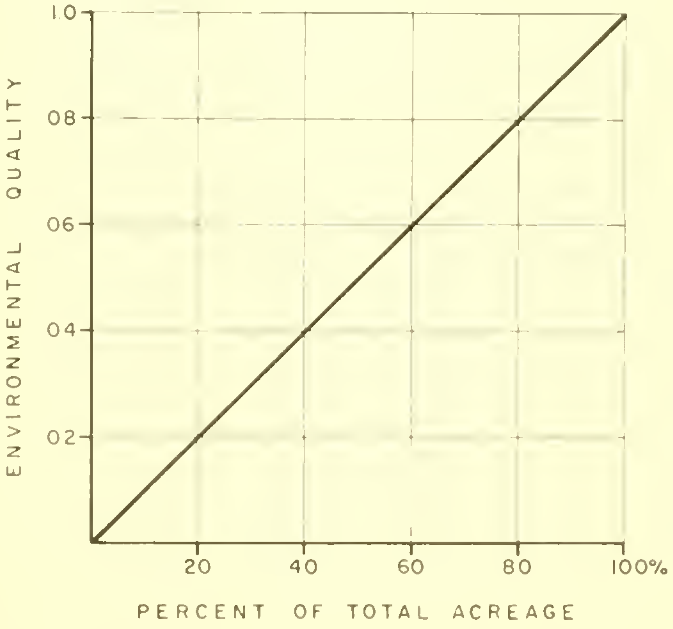


FIGURE 9. COMMERCIAL FISHERIES

The economic threshold for commercial fisheries is about $1,000. For dollar values intermediate between two levels, interpolation is necessary to determine the exact value of the modifier. (Note the logarithmic nature of the weighting.) The modifier times the inhabited area is the weighted area "with" or "without" the project. This product divided by the total available area is the parameter estimate used in the value function:

$$\text{Parameter Estimate} = \frac{\text{Area Inhabited x K}}{\text{Maximum Habitat Area}} \times 100 \ , \qquad (9)$$

where

K = Weighted dollar value.

Natural Vegetation (Aquatic). The aquatic vegetation through photosynthesis fixes some of the energy in sunlight. Most other aquatic organisms depend directly or indirectly upon the vegetation for their source of energy or food. Because the aquatic vegetation is the foundation for many food chains, any change in the vegetation and its productivity can influence all those organisms dependent on it.

As in many other parameters, the value function for aquatic natural vegetation is linear (Figure 10). The magnitude modified by quality approach is used in measuring this parameter. The magnitude is the surface area of water and the modifier is an estimate of the quality of that water. Four basic aquatic habitats are recognized: (1) streams and rivers, (2) lakes, ponds, and impoundments, (3) wetlands, including swamps and marshes, and (4) estuarine and marine.

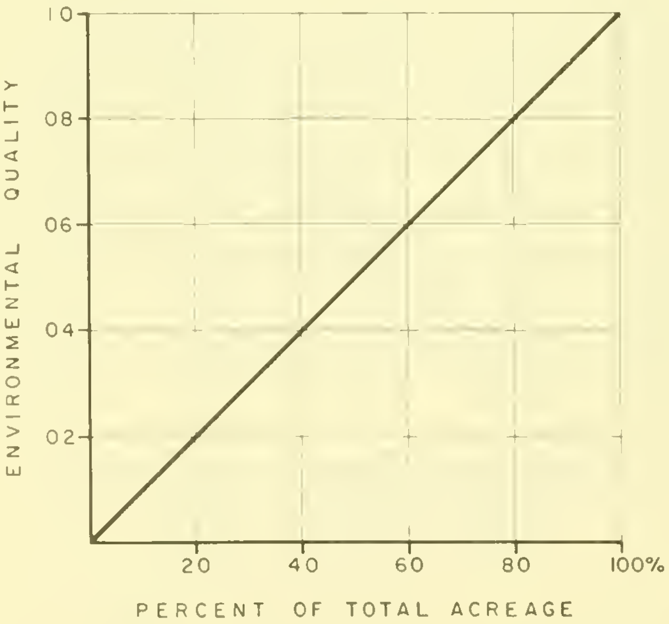


FIGURE 10. NATURAL VEGETATION

The quality of the area in streams or lakes is estimated on a 0 to 1 scale with five qualities recognized (Table 1). Many of the western states are now using a similar ranking system. A stream or lake should meet most but not necessarily all the standards included in the description in order to be assigned to a particular quality level. For this parameter, the plant productivity is particularly important in assigning areas to a quality level. Wetland quality is classified into three levels (Table 2).

The surface acreage in each quality classification is determined and multiplied by the corresponding weight to give a weighted acreage. The sum of the weighted acreages divided by the total aquatic surface acreage and multiplied by 100 is the percent value of the parameter "with" or "without" the project:

$$\text{Parameter Estimate} = \frac{\sum_{1}^{N} (\text{Surface Acreage} \times K)}{\text{Total Water Surface Area}} \times 100 \quad , \qquad (10)$$

where

N = Number of quality areas

K = Water quality classification.

Changes in water surface area caused by the project should appear both in the areas of each quality type and in the total water surface area.

Pest Species (Aquatic). Aquatic pest species includes organisms harmful or annoying to man, commercial and sport fish, or waterfowl. Pest organisms acting on other populations to damage the quality of the environment in reference to man are also included. Data are usually qualitative in nature, but some measure of impact by proposed Bureau projects is needed for this important parameter.

The value function (Figure 11) and the technique for measuring this parameter are the same as for terrestrial pest species. The same categories (weeds, diseases caused by plants, diseases caused or carried by animals, and pest animals) are used as well as the same modifier – distribution of pests. The means of measuring the parameter is:

$$\text{Parameter Estimate} = \sum_{1}^{N} \text{Category Weight} \times K \times 100 \quad , \qquad (11)$$

where

N = Number of categories

K = Distribution modifier.

TABLE 1. THE QUALITY CATEGORIES USED FOR LAKES, STREAMS, AND ESTUARIES AND THEIR WEIGHTS

Quality Category	Description	Weight
A	High plant productivity, good water quality, good year-round water supply, diverse food web, large fish population	1.0
B	Moderate-to-high plant productivity, good water quality, some water level fluctuation, diverse food web, moderate-to-large fish population	0.75
C	Moderate plant productivity, fair water quality, water level fluctuation, simplified food web, moderate fish population	0.50
D	Low plant productivity, poor water quality, water level fluctuation, simplified food web, small fish population	0.25
E	Very low to zero plant productivity, poor water quality, intermittent water supply, highly simplified food web, no fish population	0

TABLE 2. THE QUALITY CATEGORIES USED FOR WETLANDS AND THEIR WEIGHTS

Quality Category	Description	Weight
A	High plant productivity, good water supply, year-round waterfowl usage, good waterfowl production, good hunting, good migrant bird usage	1.0
B	Moderate plant productivity, fluctuating water supply, some year-round waterfowl usage, limited waterfowl production, limited hunting, good migrant bird usage	0.67
C	Low plant productivity, intermittent water supply, limited waterfowl usage, no waterfowl production, poor hunting, limited migrant bird usage	0.33

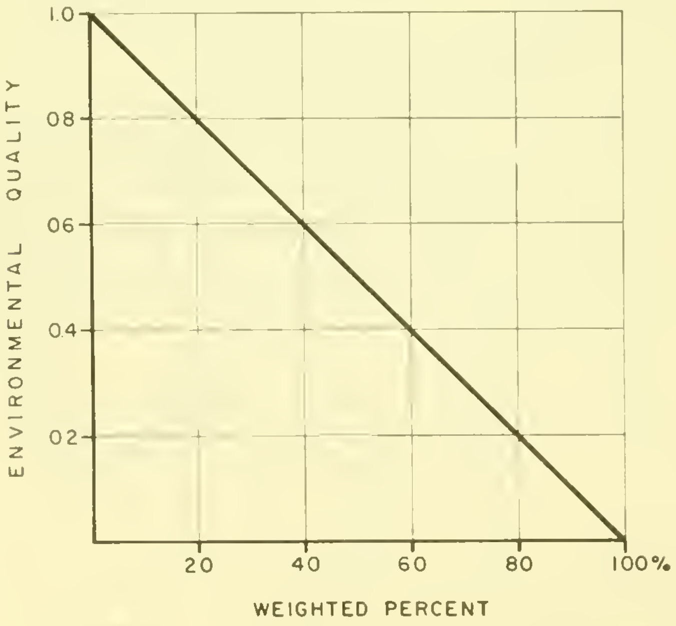


FIGURE 11. PEST SPECIES

Only aquatic species are included here. Species such as mosquitoes which spend most of their life cycle in or near water are considered aquatic pests.

Sport Fish (Aquatic). Sport fish are an important resource to fishermen and a useful indicator of the health and stability of the aquatic environment. Because of the great effort by state and Federal agencies to maintain or upgrade sport fishing in the western states and the large number of fishermen who use this resource, any change, especially a negative one, in this resource comes quickly to the attention of these agencies and sportsmen. This sensitivity makes it important that the Bureau measure the impact its proposed projects will have on sport fish.

The value function for sport fish is linear (Figure 12). Its magnitude as measured is the surface area of streams and lakes and its modifier is the quality for the sport fish of these waters. The quality is divided into the same five levels as for the aquatic natural vegetation (Table I). In assigning areas to a quality level, all the standards describing a particular level should be considered, but the size of the sport fish population is the most important. Weighted acreages are obtained by multiplying the area assigned to a quality level by the weight of that level. The sum of the weighted acreages divided by the total water surface area and multiplied by 100 is the parameter value:

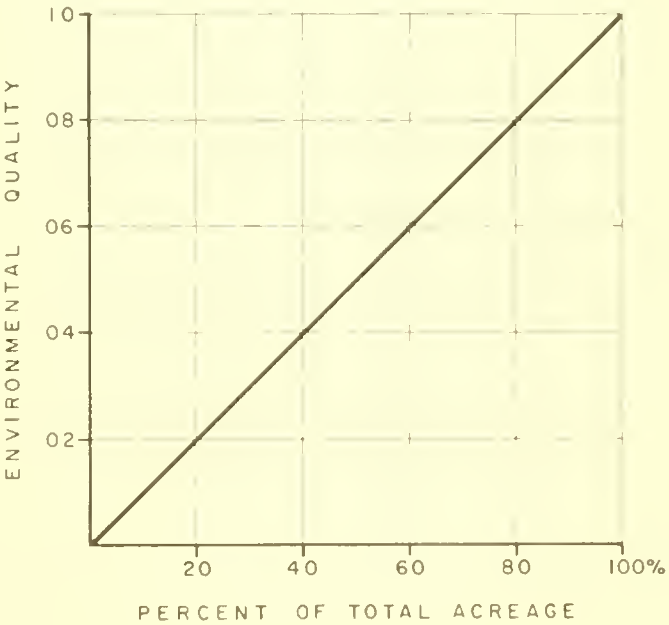


FIGURE 12. SPORT FISH

$$\text{Parameter Estimate} = \frac{\sum_{1}^{N} (\text{Surface Area} \times K)}{\text{Total Water Surface Area}} \times 100 \ , \tag{12}$$

where

N = Number of quality areas

K = Quality classification.

Changes in water surface area caused by the project should appear in both the appropriate weighted acreages and in the total water surface area.

Another excellent modifier that may be used is based on the annual sport fish production in pounds per acre or pounds per stream or river mile. The range of production data for an area could be weighted on a 0 to 1 scale as done for the quality modifier now used for this parameter. Currently, data on sport fish production in pounds per acre or mile is incomplete or lacking in most areas. Should these data become available for an area involving a Bureau project, substitution of this modifier for the one currently used should improve the accuracy of this parameter.

Waterfowl (Aquatic). Waterfowl is an important measure of the health of the animal population of the wetland habitat. The wetlands in many western states provide nesting sites for resident species and resting and feeding sites for migrants. Wetlands located along major flyways are especially important to migrant waterfowl. Changes to the wetland habitat (good or bad) by Bureau projects may alter significantly both breeding and migration success and, hence, influence waterfowl populations breeding in distant areas as well as within the project boundaries.

The linear value function for waterfowl is shown in Figure 13. Waterfowl magnitude is measured as the area of waterfowl habitat within the project boundaries, while the modifier is an estimate of the quality of that habitat in reference to waterfowl use. The total area of wetland habitat is equated with 100 percent. The quality of these wetland habitats is weighted on a 0 to 1 basis using the same three categories as for aquatic natural vegetation. The area of each of the three qualities of habitats is determined and multiplied by the corresponding modifier. Resulting weighted acreages are summed and divided by the total wetland area to give the value for the parameter "without" the project:

$$\text{Parameter Estimate} = \frac{\sum_{1}^{N} (\text{Wetland Habitat Area} \times K)}{\text{Total Wetland Area}} \times 100 \ , \tag{13}$$

where

N = Number of habitats

K = Quality modifier.

Predicted changes in the quality and acreage of wetland habitats and in the total wetland acreage are used as bove to calculate the parameter value "with" the project.

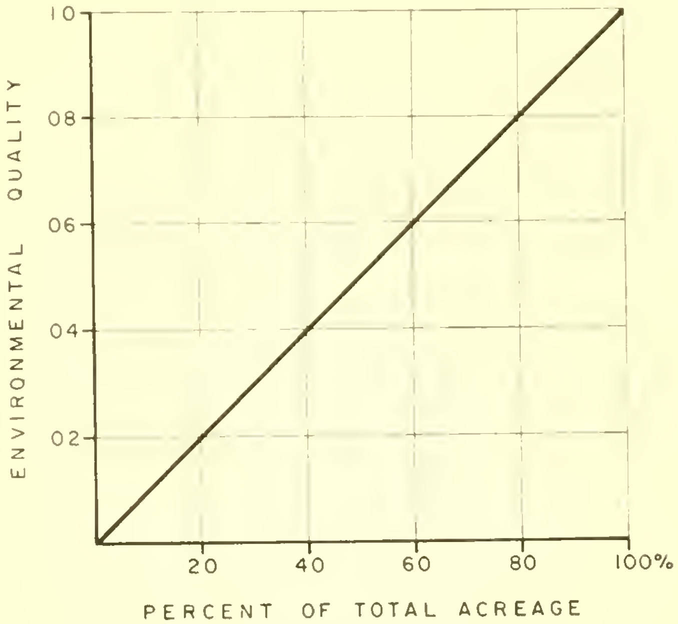


FIGURE 13. WATERFOWL

A better modifier, or a second modifier in addition to wetland habitat quality, is the waterfowl-day use of the wetlands. Waterfowl-day use would be weighted in the same manner as wetland quality with the categories being low, moderate, and high use in order of increasing weight. This modifier would provide a better estimate of the importance of the wetland habitats than would hunter success or other such measures because it would include all waterfowl – migrants, residents, game, and others. However, data on waterfowl-day use is not currently available. Areas where waterfowl habitats are important (such as northern Utah) are now measuring waterfowl-day use for their wetlands. Data should become available for these areas soon, and for less important areas, later.

Habitats and Communities

The collection of populations within a habitat is known as a community. This coexistence of species in habitats is founded upon a series of complex interactions and processes often difficult to analyze. Of the many possible parameters useful in assessing environmental impacts, several have been chosen as indicators of significant ecological impacts.

Food Web Index (Terrestrial). Communities may be visualized as a group of species interconnected by a network or web of pathways along which organic food (energy) flows and inorganic nutrients cycle. Various levels can be recognized in this food web. The lowest level includes the plants or autotrophs which fix sunlight energy while the next level is occupied by plant eaters (herbivores). Organisms feeding strictly on meat (predators) occupy the upper levels. A special category or level is recognized for those species feeding on both plants and animals (omnivores).

The size of each level in the food web is limited. The mechanism controlling the size of the herbivores is usually the predators while strict carnivores are usually controlled by the supply of their essential resources.(7)

Omnivores may be limited by their predators and/or their resource supply. The balance among herbivores, omnivores, and carnivores is important if adequate regulation of the system is to be achieved. A system out of balance is characterized by overpopulation and subsequent crash of the unregulated populations. It is important to quantify impacts which disturb the existing balance. The value function for this parameter is shown in Figure 14. The density of the organisms is the magnitude measured, which may be expressed as an absolute or relative value, such as hunter success. However, the same type of measurement should be used for all species. Because of the pyramid of numbers where lower members of the food web are more numerous than the higher ones, the logarithm of the density estimate for each species is used in the calculations to reduce the large natural differences in trophic level sizes. The sum of

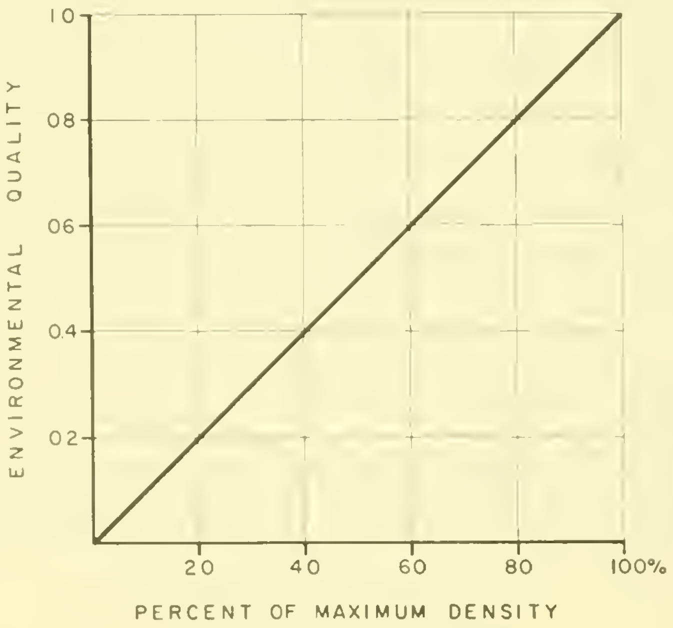


FIGURE 14. FOOD WEB INDEX

these logs is equated with 100 percent on the value function. Modifying the density estimate are the feeding habits of each species. Herbivores are given a weight of 0.33, omnivores 0.67, and carnivores 1.0. The increasing weight from herbivores to predators reflects the respective roles in the regulation process.

An estimate of the weighted density is obtained by multiplying the feeding habit by the log density of each species. The sum of the weighted logs, divided by the sum of the unweighted logs, and then multiplied by 100 produces the parameter estimate:

$$\text{Parameter Estimate} = \frac{\sum_{1}^{N} (\text{Log}_{10}\ \text{Species Density x K})}{\sum_{1}^{N} \text{Log}_{10}\ \text{Species Density}} \text{ x } 100 \ , \qquad (14)$$

where

N = Total number of species

K = Feeding Habitat modifier.

Predicted changes in the density of any species resulting from the project should be shown both in the weighted density estimates and in the unweighted total density estimate.

Land Use (Terrestrial). Land is a valuable resource and compatibility of the various kinds of land use is an important aspect of the environment. This parameter establishes a baseline for land use within the boundaries "without" the project by recognizing six land uses and ranking them in order of their compatibility with each other. "With" the project there may be changes in this baseline pattern. The location of the project or resulting developments may be very important in determining the direction and magnitude of this change. Thus, to maintain or prevent undesirably large decreases in environmental quality, consideration must be given to the siting of various developments.

The value function for this parameter is shown in Figure 15. There are six basic kinds of land use which are ranked in order of compatibility and and weighted according to their rank:

Category	Weight
Industrial	0
Commercial	0.2
Residential	0.4
Agricultural	0.6
Managed forest	0.8
Natural	1.0

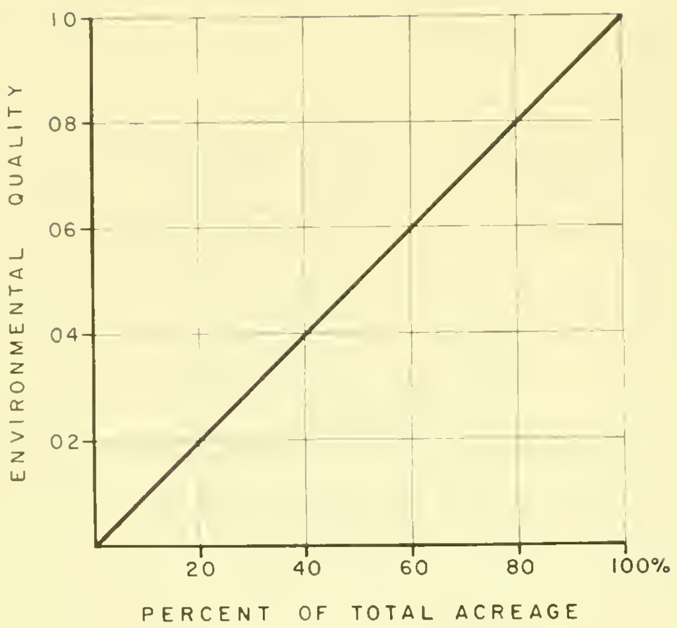


FIGURE 15. LAND USE

Natural land use is most different from industrial land use. The other categories are ranked in reference to these two extremes. Using magnitudes as a measure of area, the total land acreage within the project boundaries is represented as 100 percent on the value function. The acreage for each type of land use is determined and multiplied by the weight for that type. In cases where acreages are of two or more types lumped together and the area for each component cannot be determined, an intermediate weight is assigned. For example, if industrial and commercial acreages are combined, then that combination is given a weight of 0.1. The sum of the weighted acreages divided by the total acreage and then multiplied by 100 is the value for the parameter "with" or "without" the project:

$$\text{Parameter Estimate} = \frac{\sum_{1}^{N} (\text{Land Use Area x K})}{\text{Total Land Use}} \times 100 \quad , \qquad (15)$$

where

N = Number of land uses

K = Weighted land use types.

Land inundated by a project should be subtracted from the appropriate land use type. However, the total land area used as the divisor should not be similarly reduced in the evaluation "with" the project. This insures that the impact of the lost area is fully assessed.

Rare and Endangered Species (Terrestrial). Species which are uncommon, rare, or endangered are particularly sensitive to any additional change in the quality of the environment. Conservationists, scientists, and others are also sensitive to changes in the numbers of these species. A means for assessing the change in status of any species within the project boundaries in reference to its abundance is needed to determine the environmental impact of proposed projects.

The linear value function for terrestrial rare and endangered species is found in Figure 16. Seven categories are used and each is assigned a weight:

Category	Weight
Common	10
State Endemic	9
U. S. Endemic	7
State Rare	5
U. S. Rare	3
Endangered	1
Extinct	0

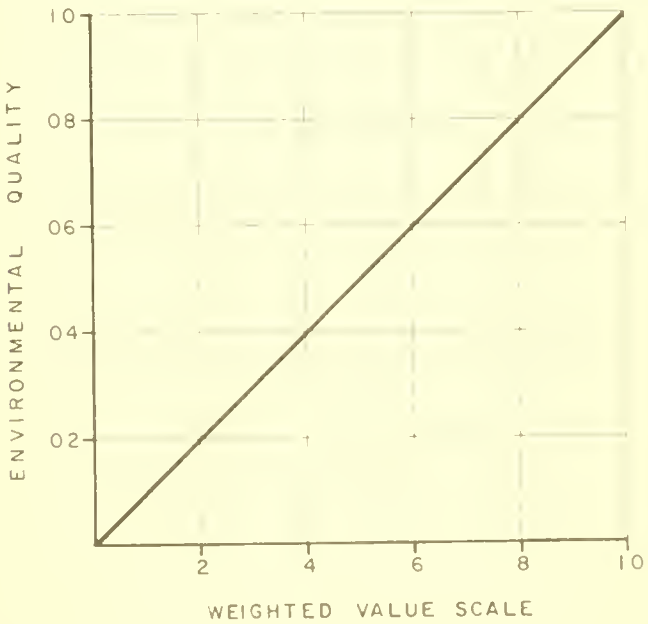


FIGURE 16. RARE AND ENDANGERED SPECIES

State endemic species are those which are found only in a single area within the state, although they may be found in other states. They are common in that one location where they are found. A species classified as state rare may occur in several locations within the state, but the total numbers of the species are small. It is found in greater numbers in other states. The lowest category (smallest weight) found within the project boundaries is used as the value for the parameter even if higher categories are also found:

$$\text{Parameter Estimate} = \text{Weight of Lowest (Least Common) Species} \qquad (16)$$

For example, if both an endangered species and a U. S. endemic species occur, the value of the lowest category is used – in this case, 1. In cases where there are more than one species within the lowest category, an additional classification system is used:

3 State endemics = 1 U. S. endemic
3 U. S. endemics = 1 State rare
3 State rares = 1 U. S. rare
3 U. S. rares = 1 endangered
3 Endangered = 1 extinct

For example, if the lowest category within the boundaries is the state rare and it contains two species, the parameter value would be 4. If there were three species in this category, the parameter would equal 3. In order to predict the impact of the proposed project, both the direct and indirect effects on these species must be examined. Construction may directly destroy individuals or may damage the habitats required by them, thus altering breeding success or some other critical life cycle process.

Species Diversity (Terrestrial). Species diversity is an often measured parameter which may be used as a measure of the stability of the system. General trends which have been noted for species diversity measurements are (1) successional stages have lower diversity than the climax and (2) extreme environmental conditions have lower diversity than mesic conditions. This parameter is designed to measure these changes in the stability of the environment as a result of Bureau actions.

The value function again is linear (Figure 17). The diversity measure used is based on the logarithm of the density of the individuals of the dominant terrestrial plant species. These plants are used as indicators of overall terrestrial diversity. Data on species and density of the dominant plant species are collected from some of the different habitats in the terrestrial ecosystems within the project boundaries.(8) The log of the number of individuals (y-axis) is plotted against the number of species (x-axis) and a regression line is fitted to the data for each habitat. The number of species per 1,000 individuals is taken from each regression line. The mean number of species per

1,000 individuals for all habitats sampled is the value of the parameter "with" or "without" the project:

$$\text{Parameter Estimate} = \frac{\text{Mean Number of Species}}{1{,}000 \text{ Individuals}} \quad . \tag{17}$$

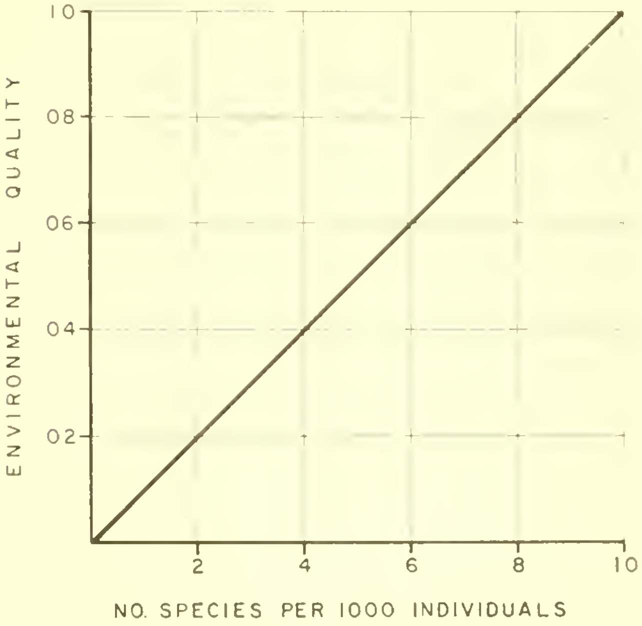


FIGURE 17. SPECIES DIVERSITY

Aid in predicting the changes caused by the proposed project in the number of species and individuals in a particular habitat may be obtained by examining this parameter value for projects already completed in a similar habitat.

Food Web Index (Aquatic). Regulation of aquatic species density is an important ecological process. Regulation is accomplished by the same mechanisms listed for the terrestrial food web index. The balance among herbivores, omnivores, and predators is important to the process of regulation. It is important to measure the existing balance with the system and determine any changes in the balance which would be caused by the proposed project.

The value function, Figure 18, and the techniques used in arriving at the "with" and "without" values for this parameter are exactly the same as the function and methods used for the terrestrial food web index:

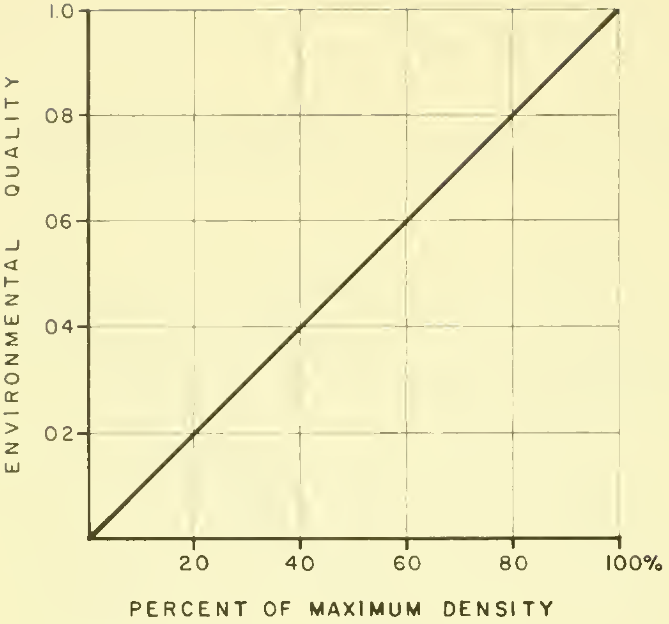


FIGURE 18. FOOD WEB INDEX

$$\text{Parameter Estimate} = \frac{\sum_{1}^{N} (\text{Log}_{10}\ \text{Species Density x K})}{\sum_{1}^{N} (\text{Log}_{10}\ \text{Species Density})} \text{ x } 100 \quad , \qquad (18)$$

where

N = Total number of species

K = Feeding habitat modifier.

Rare and Endangered Species (Aquatic). Aquatic rare and endangered species are, like their terrestrial counterparts, very sensitive to changes in the environment. Recognition of their presence in the project boundaries and the planning of the proposed actions to have either no detrimental effect or a positive effect is important for the maintenance of environmental quality.

The value function, Figure 19, and the measurement of this parameter are identical with the function and techniques used for terrestrial rare and endangered species:

Parameter Estimate = Weight of Lowest (Least Common) Species (19)

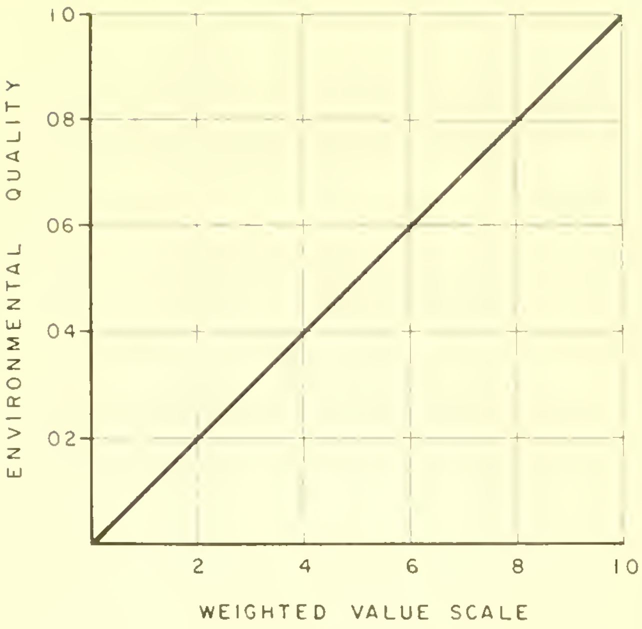


FIGURE 19. RARE AND ENDANGERED SPECIES

Care must be taken to examine both direct effects of proposed projects as well as indirect delayed effects.

River Characteristics (Aquatic). The impoundments created by Bureau projects not only inundate land, they also inundate rivers and streams changing flowing water to standing water habitats. Such changes may destroy valuable fishing areas and completely alter the aquatic biota, or they may bring about major beneficial effects. These changes are of growing concern to state and local agencies as well as the public and must be measured.

The value function is found in Figure 20. The river characteristics are evaluated on the basis of water temperature and flow. Each of the five categories recognized is given a weight:

Category	Weight
No flow, dry	0
Hot spring	0.25
Fluctuating	0.50
Warm	0.75
Cold	1.00

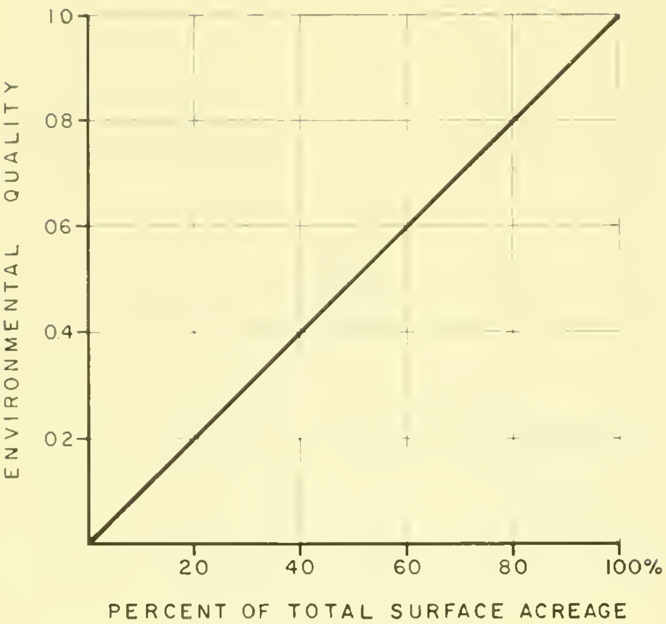


FIGURE 20. RIVER CHARACTERISTICS

The magnitude for this parameter is river and stream surface area, and its total surface acreage is equal to 100 percent on the value function. The acreage of each category is determined and multiplied by the corresponding weight. In cases where the river characteristics are intermediate between two categories, some appropriate intermediate weight should be assigned. The sum of the weighted acreages divided by the total river and stream acreage "without" the project and multiplying by 100 is the value "with" or "without" the project:

$$\text{Parameter Estimate} = \frac{\sum_{1}^{N} (\text{Category Area x K})}{\text{Total River Surface Area}} \times 100 \quad , \qquad (20)$$

where

N = Number of categories

K = Category weight.

Changes in river and stream acreage are reflected in the weighted acreages but not in the total acreage, which remains the same in order to show river and stream area lost to the project.

Species Diversity (Aquatic). Aquatic species diversity is used as a measure of stability. A low species diversity is considered characteristic of a successional stage or an extreme environmental condition. This parameter is especially important in view of the Bureau's water management projects.

The value function, Figure 21, and the techniques for evaluating aquatic species diversity are the same as those used for terrestrial species diversity. However, in this case the benthic invertebrates are used as the indicator group. Again, a variety of aquatic habitats are sampled and the mean number of species per 1,000 individuals is used as the parameter value.

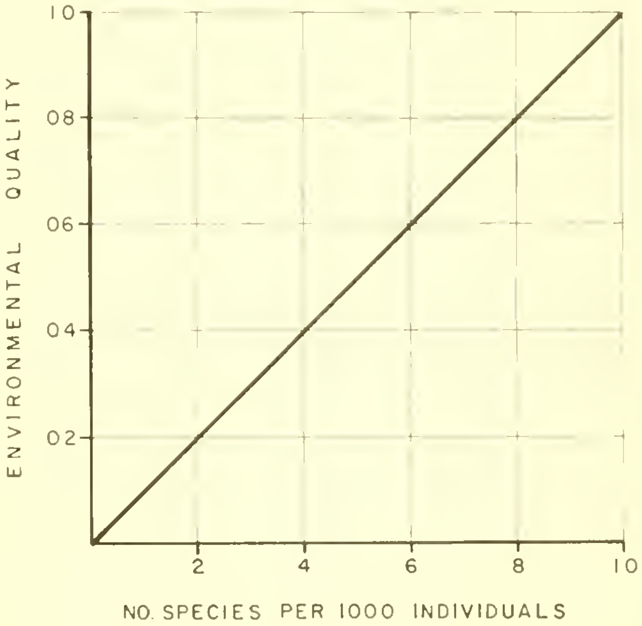


FIGURE 21. SPECIES DIVERSITY

$$\text{Parameter Estimate} = \frac{\text{Mean Number of Species}}{\text{1000 Individuals}} \qquad (21)$$

Changes resulting from the proposed project may be predicted by measuring this parameter in similar habitats where projects are completed and operating.

Ecosystems

The ecosystem level found in the first report to the Bureau has been dropped as a separate category to which EQ points are assigned and parameters measured. Two reasons prompted this change. First, the productivity measurement originally used as a parameter at the ecosystem level has been used here as a quality modifier at the lower levels. Second, the availability and reliability of existing data and data acquisition techniques for nutrient budgets, hydrologic budgets, and decomposer productivity are inadequate. Furthermore, the ability to interpret these data is limited. As the frontiers of ecological knowledge are thrust forward, the ability to acquire and interpret ecosystem data accurately will no doubt improve. When such ability becomes a reality, the Bureau should incorporate appropriate ecosystem parameters into their EES.

Environmental Pollution

The natural environment is an intricate system. It consists of living and nonliving elements which are tied together by a balanced design. Any resource development within the environment should, therefore, consider the interrelationships and the balance that exists in this natural system. A misallocation of one natural resource can have adverse effects on the entire system.

Man interacts with the natural system in many ways. Generally, these interactions cause changes in the quality, quantity, and distribution of the natural components in the system. Therefore, by measuring physical, chemical, and biological parameters, the impact of man's interaction with the environment can be better understood. This information can then be used to assess the degree of change and the importance of the change on the natural environment. This approach for the assessment of environmental quality is not new. It has been used for many years by sanitary engineers, water resource managers, ecologists, etc., to assess water quality and quantity.

Of all the environmental categories used in the EES, parameters for environmental pollution are the most well developed because they have had the greatest past use. Many of the parameters are relatively easy to measure or estimate, and have a broad base of available information.

The Bureau of Reclamation activities affect the environment both directly and indirectly. Because of the nature of the Bureau of Reclamation projects, a major portion of its direct impact on the environment will be in relation to water, while many of the indirect effects of Bureau projects will in turn be related to land, air, and noise. Environmental pollution parameters have been grouped into four components: water pollution, air pollution, land pollution, and noise pollution.

Water Pollution

Water has many uses in today's society. It is a necessary part of man's, plants', and animals' life cycle; it is a source of man's recreation and navigation; it is a necessary part of industrial and agricultural processes; it is a provider of energy; and it is a carrier and assimilator of waste materials. Many of these uses are affected both favorably and adversely by Bureau of Reclamation activities. Parameters that are used to measure any change in water quality, quantity, and/or distribution can be grouped for discussion purposes into the three general types of indicators: physical, chemical, and biological. The physical classification includes the measurement of environmental changes particularly brought about by changes in a river's discharge. These changes could take place in a particular reach or in an entire watershed. Also included in the physical classification are environmental parameters related to changes in a river's regimen or sediment balance.

Physical changes also affect the water quality of a river. Natural chemical quality – dissolved oxygen, nutrients, acidity – can be altered by changes in discharge caused by the natural fluctuations in rainfall and runoff, by the man-made changes caused by impoundments, by river regulation, and by water diversions. Other activities that affect water quality are irrigation return flows and waste discharges. A third major indicator type for water quality is the biological activity that exists in the water. In many ways biological activity is the best indicator of environmental quality because it is an output parameter, i.e., it measures the effect that both physical and chemical changes have had on the environment.

In developing the water quality value functions, maximum use was made of existing literature on water quality criteria and on previous attempts to relate water quality to some overall index. Specifically, heavy reliance was made of data on water quality as outlined by McKee and Wolf(9) and by the Committee on Water Quality Criteria.(10) Although these publications do not suggest overall index levels, they provide considerable background that can be used in such activities. In addition, results of two previous attempts at indexing water quality reported in the literature were reviewed. One effort was reported by Horton(11) who discussed an approach recommended by ORSANCO staff for developing a water quality index. The second effort reported by Brown(12, 13) described results of a questionnaire survey conducted by the National Sanitation Foundation (NSF) to profile the attitudes of a large group of professionals; in so doing NSF developed value functions for the following water quality parameters: dissolved oxygen, temperature, fecal coliforms, turbidity, pH, BOD, nitrates, phosphates, and total solids. Throughout the following discussion of the water quality value functions, reference is made at appropriate places to respective results of the ORSANCO and NSF work.

Basin Hydrologic Loss. The parameter "basin hydrologic loss" is an attempt to relate crucial elements of the overall hydrologic budget to their impact on environmental quality. This type of parameter is especially appropriate for evaluating the impact of Bureau of Reclamation projects because of the influence that these projects have on hydrologic budgets through evaporation losses from irrigated areas and reservoirs. Basin hydrologic loss is quantified as a ratio of two factors. The denominator of this ratio is the total natural discharge that would be measured at the mouth of a river if there were no man-made developments in the basin. This number can be calculated by adding to the existing average annual discharge at the mouth of the river, the estimated evaporative and other net water losses due to developments in the basin. The numerator of the ratio is the average annual hydrologic loss in the basin due to evaporative and other losses resulting from man-made developments in the basin.

Clearly the basin hydrologic loss, as defined by the ratio described above, will range from 0 to 1.0. Although this ratio is not a commonly employed or measured parameter of environmental quality, Battelle-Columbus believes that it embodies crucial factors contributing to the overall environmental impact of Bureau of Reclamation projects. Because the parameter is unconventional, there are no guidelines to fall back on in developing a value function. Nevertheless, the following criteria seem to be logical:

- As the basin hydrologic loss rates increases from 0 to a finite value, the environmental impact of the first units of water lost are less adverse than losses of each subsequent unit; hence, the value function should have a gradual slope in the region of zero loss.
- Once a major fraction, say 90 percent, of the available natural discharge is lost through "basin development", the remaining water is extremely crucial and the marginal impact of the loss of each additional unit of water is more serious than the last. This suggests a value function having a steep slope where the ratio approaches 1.0.

The above two considerations suggest a value function concave toward the origin as shown in Figure 22. The curve shown is in Battelle-Columbus' judgment, a reasonable compromise that must continually be reexamined as the Bureau of Reclamation staff and its contractors become more accustomed to thinking in terms of the ratio described.

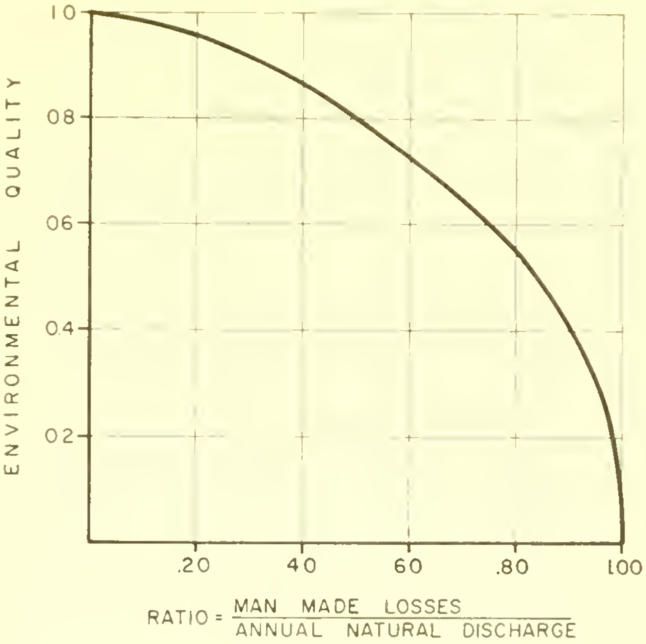


FIGURE 22. BASIN HYDROLOGIC LOSS

Biochemical Oxygen Demand. Biochemical oxygen demand (BOD), one of the most widely used parameters of water quality, is a surrogate indicator of the effect of a combination of substances and conditions. Specifically, BOD is a measure of the amount of dissolved oxygen that will be depleted from water during the natural biological assimilation of organic pollutants.

BOD is important only insofar as it promotes the depletion of dissolved oxygen or the growth of undesirable benthic organisms. In a slow sluggish stream or reservoir a BOD of 5 mg/l might be sufficient to produce undesirable conditions, whereas a swift mountain stream might easily handle 50 mg/l of BOD without significant deleterious effects. This is because swift moving streams have a greater capacity for reaeration and for preventing the accumulation of high BOD materials in bottom deposits than do sluggish streams or reservoirs. Thus, the value function for BOD must be structured to reflect these differences. It is seen that the NSF value function falls in between the value functions provided in Figure 23 for the two extreme conditions outlined above. The value function for the sluggish stream or reservoir is characterized by a much more sudden decrease in quality per unit of additional BOD than is the value function for the swift stream.

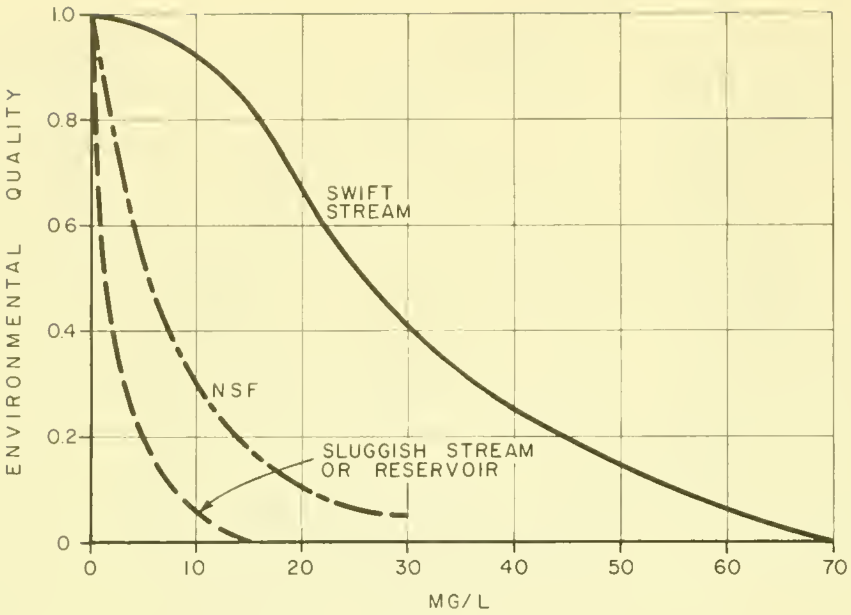


FIGURE 23. BOD

Dissolved Oxygen. Dissolved oxygen is perhaps the most commonly employed parameter of water quality. Low levels of dissolved oxygen adversely affect fish and other aquatic life and the total absence of dissolved oxygen will lead to the development of an anaerobic condition with the attendant odor and esthetic problems.

The saturation concentration of dissolved oxygen in water depends on water temperature and on dissolved solids content; the ability of water to hold dissolved oxygen decreases with increases in temperature or dissolved solids. Further, increased temperatures increase the rates at which dissolved oxygen is depleted by the life processes of fish and aquatic life and by the stabilization of BOD materials.

The oxygen requirements of fish vary with the species and age of the fish. Cold water fish seem to require higher oxygen concentrations than do the "coarse" fish (e.g., carp, pike, eel), probably because the former are more active and predatory.

Notwithstanding these variations, it may be stated that the range of 3-6 mg/l is the critical level of dissolved oxygen for nearly all fish. Below 3 mg/l, further decreases in dissolved oxygen are important only insofar as the development of local anaerobic conditions is concerned; the major damage to fish and aquatic life will already have been done. Above 6 mg/l, the major advantage of additional dissolved oxygen is as a reserve or buffer to handle shock loads of high oxygen demanding waste loads. These factors are reflected in the "S-shape" of the value function (Figure 24). The value function shown in Figure 24 is identical to the one published by NSF if one assumes a saturation concentration of 9 mg/l (the NSF value function was constructed in terms of percent saturation instead of absolute dissolved oxygen concentration).

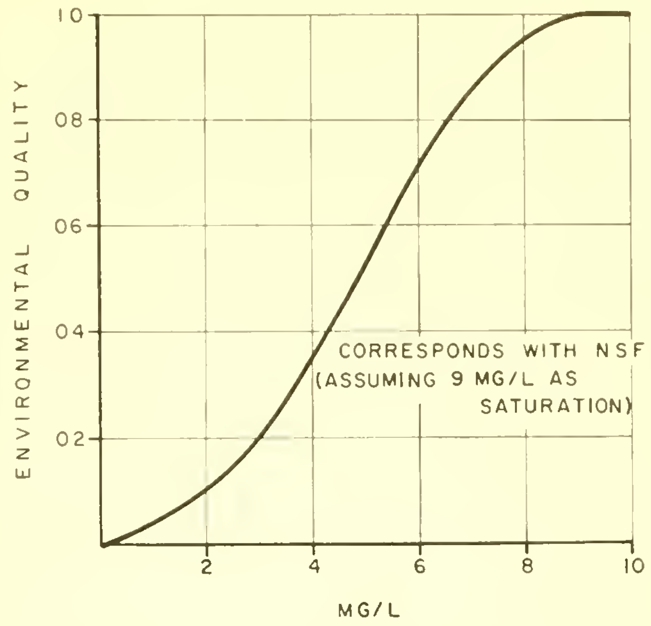


FIGURE 24. DISSOLVED OXYGEN

Fecal Coliforms. The presence of coliform organisms in water is regarded as evidence of fecal contamination. The importance of such evidence in assessing water quality has declined, however, in the last 25 years due to advances in preventive medicine which have all but eliminated the highly debilitating gastrointestinal diseases that can be transmitted through contamination of water supplies by disease carriers. The inability to distinguish between human and animal fecal coliforms further complicates the interpretation of coliform data in assessing water quality.

Coliform data continue to retain some importance, however, because of existing implications that viral diseases can be transmitted through the fecal contamination of water supplies. Also, indirect routes such as the contamination of foods with fecally contaminated irrigation water and the accumulation of contaminants by oysters, clams, and mussels from fecally contaminated marine waters continue to be areas of concern.

The value function for fecal coliform is shown in Figure 25; the coliform scale is logarithmic and is measured in the conventional units of MPN/100 ml. Value functions developed by NSF and ORSANCO are also shown. The function developed by Battelle-Columbus is midway between the two extremes suggested by NSF and ORSANCO; the curve is S shaped to reflect the relatively inconsequential nature of unit changes at the lower and upper ends of the scale, and the critical nature of the region 10^2 - 10^4 MPN/100 ml.

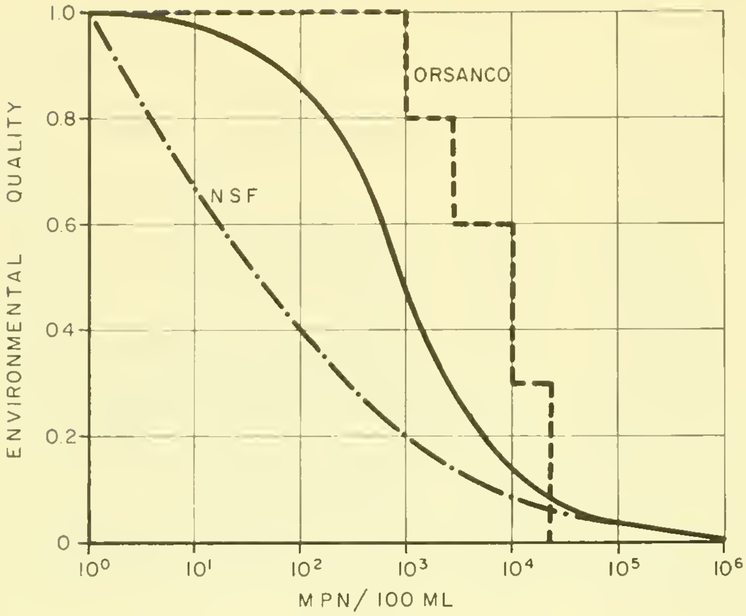


FIGURE 25. FECAL COLIFORMS

Inorganic Carbon. Carbon, along with nitrogen and phosphorus, is one of the three basic elemental nutrients needed to sustain aquatic life. The pathways by which carbon can be utilized are diverse and vary with the total chemistry of the environment involved as well as with the composition and distribution of specific aquatic species. Carbon transformation in aquatic environments resolves around the synthesis and degradation of organic matter – i.e., the reduction of inorganic carbon into organic carbon, and then the subsequent oxidation of organic carbon into inorganic carbon, with a strong interdependence of these reactions upon one another. Although inorganic and organic carbon concentrations are both important in characterizing the quality of aquatic environments, total inorganic carbon (carbon dioxide, bicarbonate, and carbonate) is best for use in the EES. This is true because inorganic carbon is the main carbon source for photosynthetic organisms, and because organic carbon must usually be broken down into inorganic carbon before use by bacteria. The value function, Figure 26 for inorganic carbon suggests an optimal range of 20-80 mg/l as carbon; that above 150 mg/l as carbon, conditions may become excessively productive; and that a zero total organic carbon would be nonproductive. Although it is recognized that precise judgments as to the overall effect of given nutrients must take into account a myriad of related factors including the level of other nutrients, it is felt that the value function described above provides one useful first level indicator of overall aquatic environmental quality.

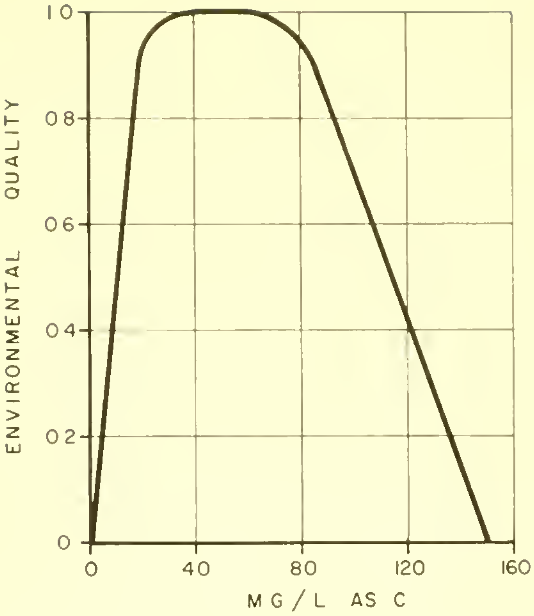


FIGURE 26. INORGANIC CARBON

Inorganic Nitrogen. Nitrogen, along with carbon and phosphorus, is one of the three basic elemental nutrients needed to sustain aquatic life. Specifically, inorganic nitrogen primarily in the form of ammonia and nitrate, are the major forms of nitrogen nutrient available to eutrophic organisms. Organic nitrogen becomes available only after conversion to inorganic forms by bacterial action. Industrial and municipal wastes and fertilizer residues in agricultural runoff are the major sources of inorganic nitrogen in surface water. As in the case for carbon and phosphorus, trace quantities are essential to support aquatic ecosystems; below approximately 0.3 mg/l inorganic nitrogen (as nitrogen) is a nitrogen-deficient range. Further, it has been reported that among United States waters supporting a good fish population, 95 percent have a nitrate concentration less than 1.0 mg/l. These and other data suggest that concentrations above 1.0 mg/l of inorganic nitrogen are less than optimal. Further, 10 mg/l as nitrogen is inhibiting. These considerations have led to the development of the value function shown in Figure 27. It is realized, of course, that more precise judgments really require information on the levels of other nutrients plus other parameters of the aquatic environment.

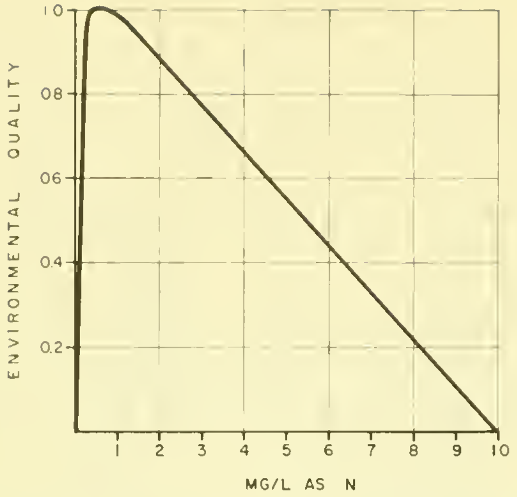


FIGURE 27. INORGANIC NITROGEN

Inorganic Phosphate. Phosphorus, along with nitrogen and carbon, is one of the three basic elemental nutrients needed to sustain aquatic life. Further, various forms of inorganic phosphorus have been the most commonly discussed contributor to eutrophication. Sources of phosphorus include domestic and industrial wastes, detergents, and agricultural runoff containing fertilizer material; the latter perhaps the prime consideration vis a vis the impact of Bureau of Reclamation projects. Although the concentration of inorganic phosphorus that will produce problems varies with the nature of the aquatic environment and the levels of other nutrients, some general criteria are available for developing a value function (Figure 28). Specifically, below 0.005 mg/l as phosphorus, one enters a nutrient-deficient region; above 0.02 mg/l as phosphorus, one gets into a region of potential algae bloom; above 0.1 mg/l as phosphorus, one is in an excessively enriched region which is assigned an environmental quality of zero.

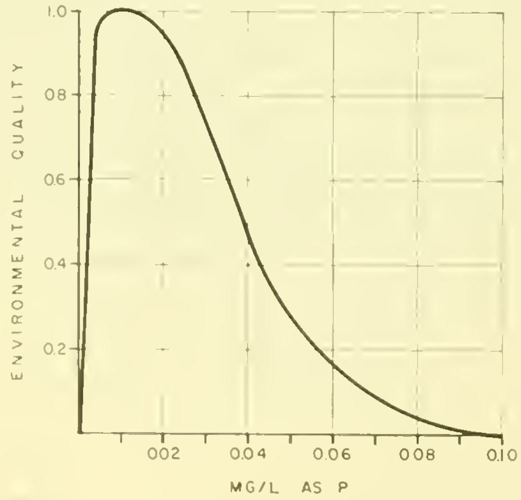
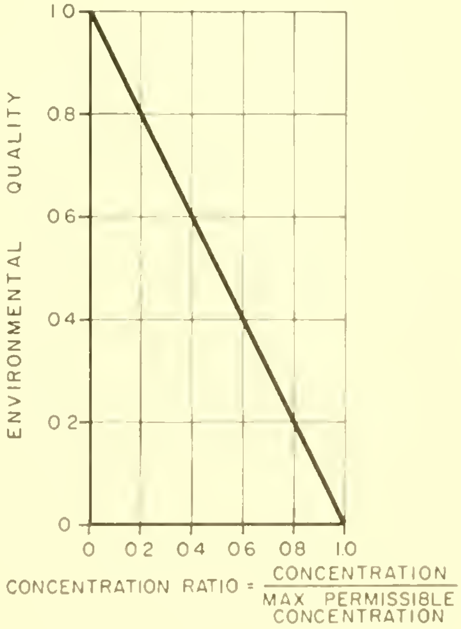


FIGURE 28. INORGANIC PHOSPHATE (PO_4)

Pesticides. Pesticides include the broad category of insecticides, herbicides, and algicides. The effect of pesticides on environmental quality is one of the most hotly debated environmental issues, both in professional circles and in the public media. Effects of pesticides vary widely from pesticide to pesticide and from species to species. Information related to maximum permissible concentration of various pesticides in various habitats may be found in Water Quality Criteria,(10) which recommends that 1/10 - 1/100 of the 48 hour TLm value be used as a guide in determining maximum permissible concentration. TLm values for some 60 insecticides with respect to fish listed in Water Quality Criteria range from a high of 47,000 μg/l for Cryolite (with respect to rainbow trout) to a low of 0.2 μg/l for Endrin (with respect to bluegill).

Because maximum permissible concentrations vary so widely, and because it would be too unwieldly to have a separate value function for each pesticide, it was decided that a useful basis for developing a value function would be the ratio of existing (or expected) concentration of a given pesticide to its respective maximum permissible concentration. If only one pesticide is present the value function employed in Figure 29 is used directly where (for lack of criteria suggesting otherwise) environmental quality varies linearly from 1.0 (zero pesticide) to 0 (when the existing or expected concentration reaches the maximum permissible concentration).



NOTE IF n PESTICIDES ARE PRESENT

$$EQ = \left(\frac{\sum_{i=1}^{n} EQ_i}{n} \right) \times \left(0.9 \right)^n$$

FIGURE 29. PESTICIDES

If more than one pesticide is present, the one with the highest concentration ratio is not a satisfactory surrogate nor can concentrations be added meaningfully. To account for this situation the following expression was developed

$$EQ = \frac{\sum_{i=1}^{N} EQ_i}{N} \times (0.9)^N \,, \tag{22}$$

where

EQ = Overall environmental quality re: pesticides

EQ_i = Environmental quality for pesticide i obtained from Figure 29

N = Number of pesticides.

This expression is quite arbitrary but does provide a means for aggregating the effects of multiple pesticides such that the negative effects of multiple pesticides are reflected.

pH. pH is a measure of the hydrogen ion concentration of water. High pH reflects a low concentration of hydrogen ions — i.e., an alkaline situation, and low pH reflects a high concentration — i.e., an acidic situation. The breakpoint between alkaline and acidic waters is pH = 7; at this point the hydrogen ion and hydroxide ion concentrations are both equal to 10^{-7} moles/l. pH should not be confused with acidity (alkalinity) which is a measure of the ease with which the pH of acid (alkaline) waters can be changed. Waters with a high acidity are those whose pH is less than 7 and whose pH is not easily changed. Waters with high acidity or high alkalinity are referred to as being highly buffered.

Although pH affects the suitability of water for various uses, the best measure of its impact on environment quality is its effect on fish and aquatic life. Since the natural pH of aquatic ecosystems varies from one locale to another, the best measure of pH is in terms of departure from natural levels. Due to the lack of evidence to strongly suggest a more suitable function, a "bell-shaped" curve about this natural pH was selected for the value function (Figure 30).

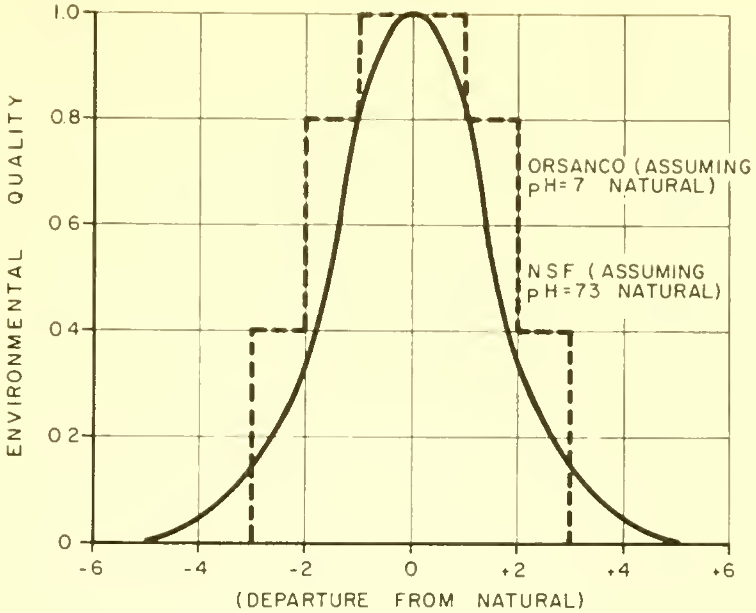


FIGURE 30. pH

Stream Flow Variation. The nature and magnitude of stream flow variations are critical factors governing the type of ecological system that will develop and survive in a given water course. If the pattern of stream flow variation is changed markedly from that which is natural, a subsequent disruption of the natural ecology may result. A primary consequence of Bureau of Reclamation dam and reservoir projects is a significant change in the pattern of stream flow variation.

Although the potentially adverse effects of stream flow changes are rather widely recognized, at least in a subjective way, accepted means for quantifying these effects do not exist. Thus, the approach outlined below represents a first attempt and will certainly need refinement as the Bureau and others obtain experience with its use.

The basic criteria employed in developing the value function for stream flow variation was that the more rapid and extensive the variation, the worse the condition from an environmental quality viewpoint. An example of an extremely poor condition observed during the field tests was downstream of the existing Oneida Narrows power plant where the predominant daily variation (due to power releases) is about 40:1 (Max:Min), with this change occurring in a period of about two hours. Variations of this magnitude and frequency are highly detrimental to river ecology.

The value function is structured around three essential factors and requires four separate graphs to present, Figures 31 to 34. The three factors are:

(a) The magnitude of the stream flow variation expressed as the ratio, Daily Max/Daily Min; four discrete values for the flow ratio are employed

	Daily Max/Daily Min
1	<2:1
2	2:1 – 10:1
3	10:1 – 50:1
4	>50:1

(b) The number of days per year (expressed as a percentage of 365) on which the above flow ratios occur

(c) The predominant period of time over which the flow changes from a maximum to a minimum value or vice versa; three discrete time periods are employed

Period	Δt, hours
1	<2
2	12
3	>24 .

Given data on these three factors one uses the four value function curves to generate an overall EQ score: $EQ = \pi_{i=1}^{n} f_i$ where n = the number of curves needed to account for the total range of flow variation. Use of the curves is illustrated in the Illustrative Analysis for the Honeyville site, in this case, the range of flow variation is less than or equal to 10:1, so only curves for f_1 and f_2 are used, i.e., $n = 2$.

Temperature. Water temperature is important primarily because of the sensitivity of fish and aquatic life to temperature changes. Although each species has an optimum temperature range, aggregate temperature effects are best handled not in terms of temperature per se, but in terms of the magnitude of departure from natural conditions. The NSF value function for temperature is also shown in Figure 35. In accord with observations for most fish, both value functions imply less serious effects for temperature changes that cool the natural environment than for those which warm it.

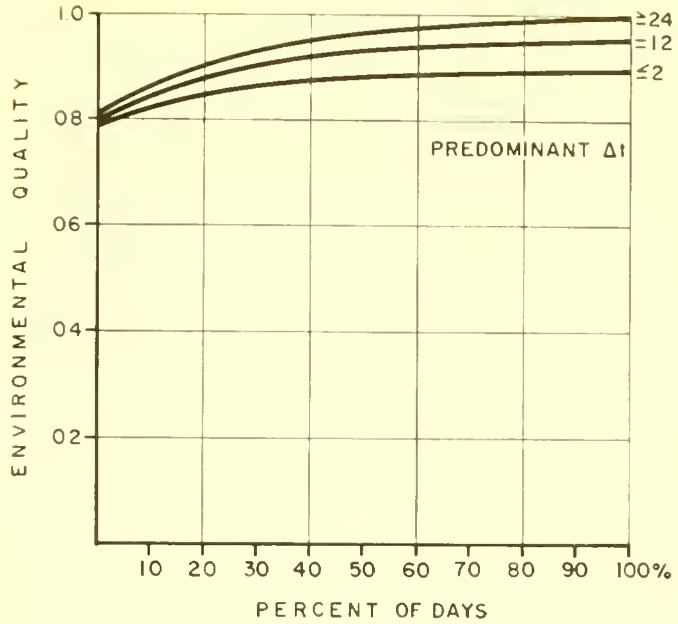


FIGURE 31. STREAM FLOW VARIATIONS, DAILY MAX/MIN ≤ 2:1

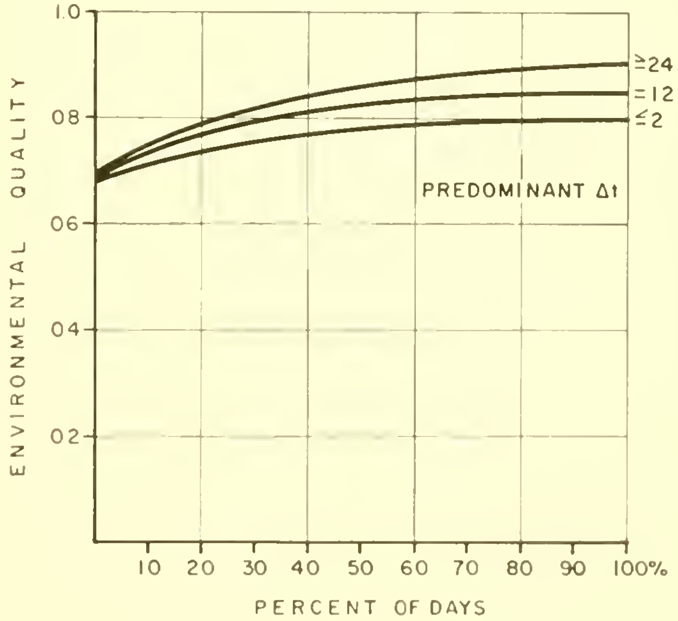


FIGURE 32. STREAM FLOW VARIATIONS, DAILY MAX/MIN ≤ 10:1

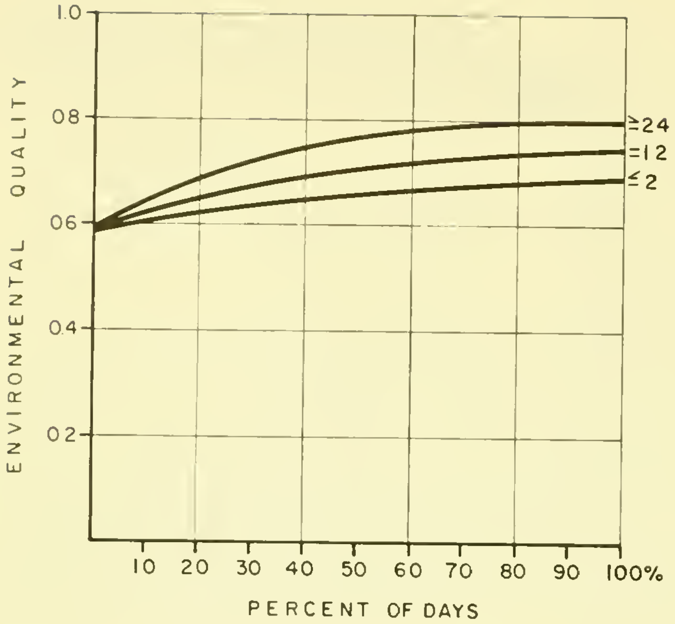


FIGURE 33. STREAM FLOW VARIATIONS, MAX/MIN ≤ 50:1

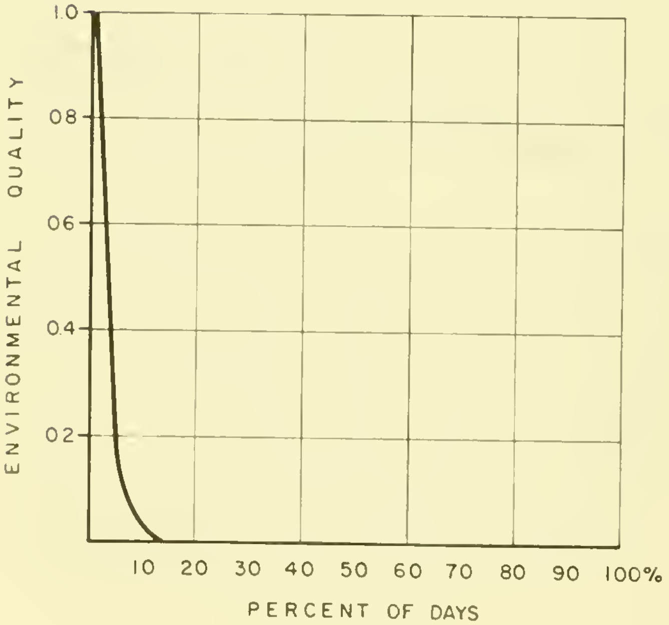


FIGURE 34. STREAM FLOW VARIATIONS, MAX/MIN > 50:1

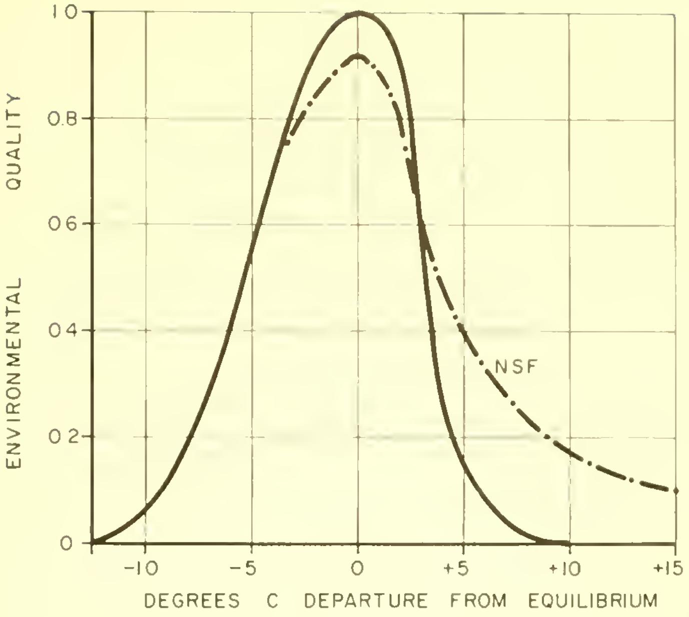


FIGURE 35. TEMPERATURE

Total Dissolved Solids. The concentration of total dissolved solids (TDS) is the aggregate of carbonates, bicarbonates, chlorides, sulfates, phosphates, nitrates, etc. of calcium, magnesium, sodium, potassium, and other substances. All salts in solution change the physical and chemical nature of the water and exert osmotic pressure; the magnitude of the change is to a large extent upon total salt concentration, commonly referred to as total dissolved solids.

Irrigated crops are highly sensitive to salt concentrations; waters containing over 2000 mg/l are of marginal value for irrigation use and waters containing 3000 mg/l are unsuitable. In contrast, the upper limit for human concentration is 4000-5000 mg/l and upper limits for some freshwater fish are as high as 5000 to 10,000 mg/l. In each case reference is only to total salt concentration and its effects on osmotic pressure. It should be pointed out that possible synergistic or antagonistic interactions between mixed salts in solution may cause different effects than those associated with the respective salts considered separately.

The value function for TDS is shown in Figure 36, along with guidelines suggested by ORSANCO. The function as developed recognizes that some finite concentration of TDS is essential at upper and lower extremes of TDS concentrations unit charges are less critical than in the transition zone which is in the neighborhood of 1000-2000 mg/l.

It is recognized that from an irrigation-use viewpoint, the value function shown in Figure 36 may seem too liberal. It must be remembered, however, that the purpose of the value function is to indicate overall quality not suitability for a given use. Use is determined by quality not vice versa.

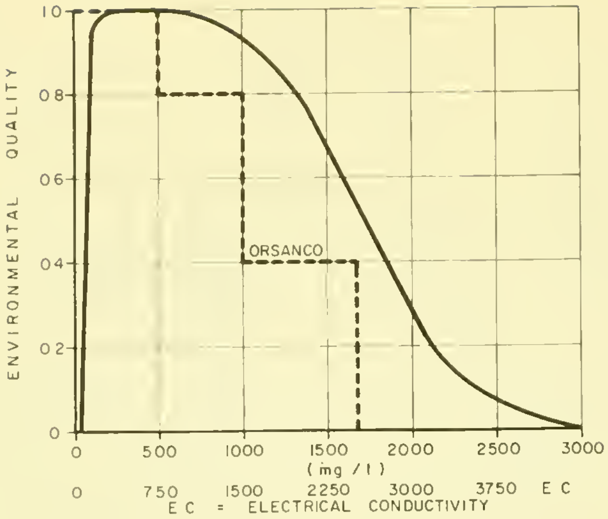


FIGURE 36. TOTAL DISSOLVED SOLIDS

Toxic Substances (Except Pesticides). The spectrum of toxic materials is extremely large and highly diverse in terms of effects. Further, since knowledge of effects is extremely limited, it seems that a reasonable environmental goal is to eliminate these materials entirely from the environment. As a practical matter this will not be possible to enforce since some materials are potentially dangerous in concentrations below those which can be detected by modern water-quality analysis methods. The value function for toxic materials (Figure 37) has been structured to yield EQ = 1.0 if no toxic material is present in detectable amounts and EQ = 0 otherwise.

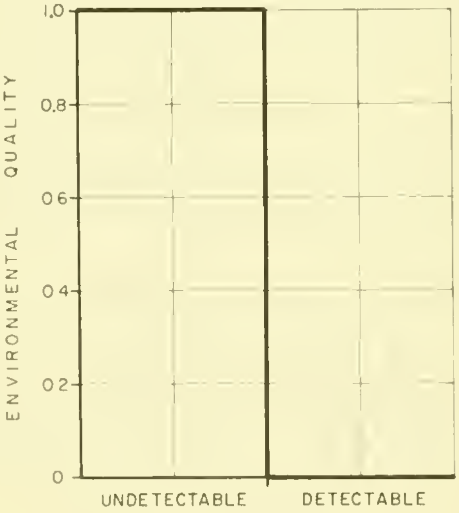


FIGURE 37. TOXIC SUBSTANCES

Turbidity. Turbidity is a measure of the extent to which light passing through water is reduced by scattering induced by suspended materials. It is, therefore, an indicator of the level of suspended matter in water. Turbidity may result from naturally present materials, microbiological processes, erosion, or from man-related activities such as waste discharge, dredgings, etc.

Excessive turbidity in water is undesirable because

- By interfering with the penetration of light it minimizes photosynthesis and thereby decreases the primary productivity upon which fish-food organisms depend
- Particulate matter can interfere directly with essential physiological functions of fish and other aquatic organisms
- It makes it difficult for fish to find food
- It can alter the temperature structure of water bodies by changing the pattern of sunlight absorption.

The value function (Figure 38) for turbidity coincides basically with that developed by NSF and reflects a gradual deterioration of quality with increasing turbidity. Because of the visual impact of even low levels of turbidity, the decrease in quality is most rapid at the low levels.

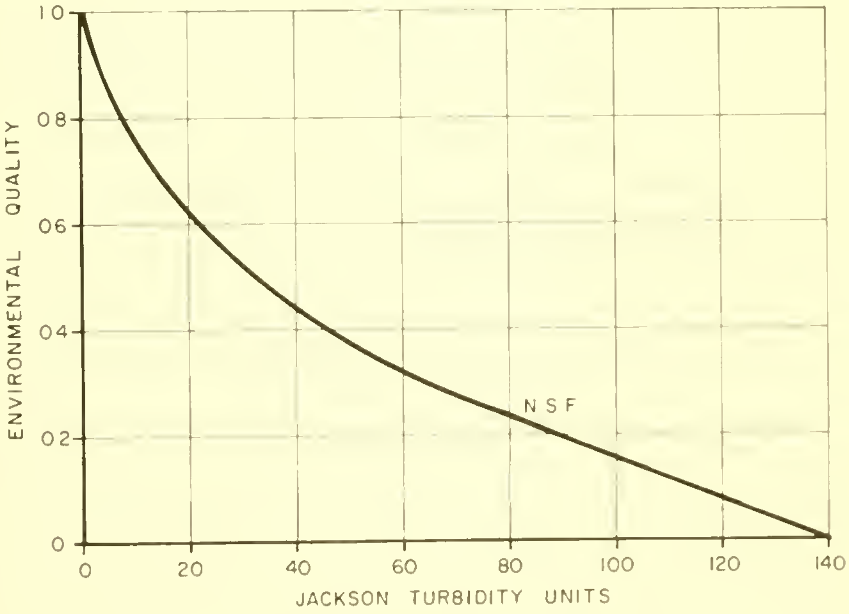


FIGURE 38. TURBIDITY

Air Pollution

The air that is necessary for life on this planet has become a sink for the wastes of industrial production, construction, energy generation, waste disposal, and transportation. The presence of these wastes in the atmosphere has in turn caused damage to natural vegetation, crops, livestock, wildlife, structural materials, and man's health. Bureau of Reclamation activities can alter the quality of air during both the construction and operation of their projects. By supplying water to power plants, industrial developments, and municipalities the Bureau can influence the air quality in the project area. Also, by developing recreation areas which in turn increase the usage of automobiles in the environment, the Bureau affects air quality.

Carbon Monoxide. Carbon monoxide is a colorless, odorless, tasteless gas formed by the combustion of carbonaceous fuels. This pollution gas emanates primarily from automobile exhausts. On the basis of tons emitted per year, carbon monoxide is often referred to as the most pervasive pollutant in the atmosphere. On a tonnage basis, it is true that more CO is emitted than any other pollutant, but this does not imply that it represents a problem out of proportion to all other pollutants. Although an air quality standard for CO exists, there is still uncertainty as to the concentrations which should be of concern when maintained for various periods of time.

Carboxyhemoglobin forms in the blood at a rate which is a function of carbon monoxide concentration. It is usually considered to be a completely reversible response, so until harmful effects occur (about 10 ppm) the value function is essentially flat (Figure 39). At toxic levels (about 40 ppm) it falls abruptly again.

Hydrocarbons. Unburned hydrocarbons as pollutants are most often petroleum products, with automobile exhaust as the major source. Their most important role is as oxidant precursors in the formation of photochemical smog.

On a typical smog day, the hydrocarbon concentration peaks twice, during and shortly after the traffic rush hours. Standards are set for short-term concentrations because of the variable source and because of the hydrocarbon contribution to photochemical smog. The value function (Figure 40) as with most atmospheric pollutants, is a flattened "S" curve; at very low concentrations hydrocarbons are innocuous or unimportant. The value function falls more rapidly as conditions for smog development appear and more slowly again in an environment which is highly deteriorated.

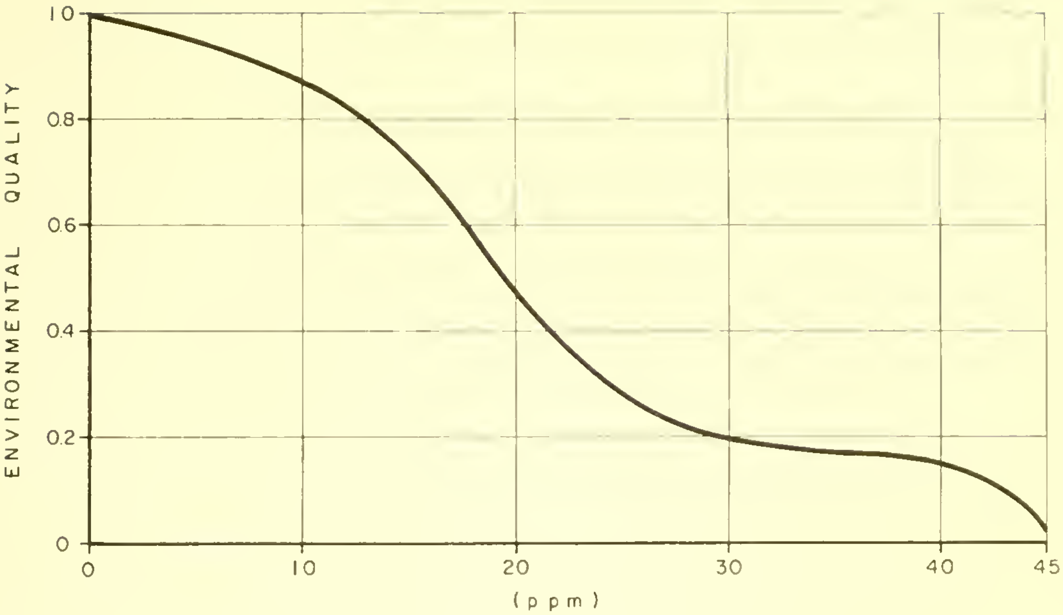


FIGURE 39. CARBON MONOXIDE

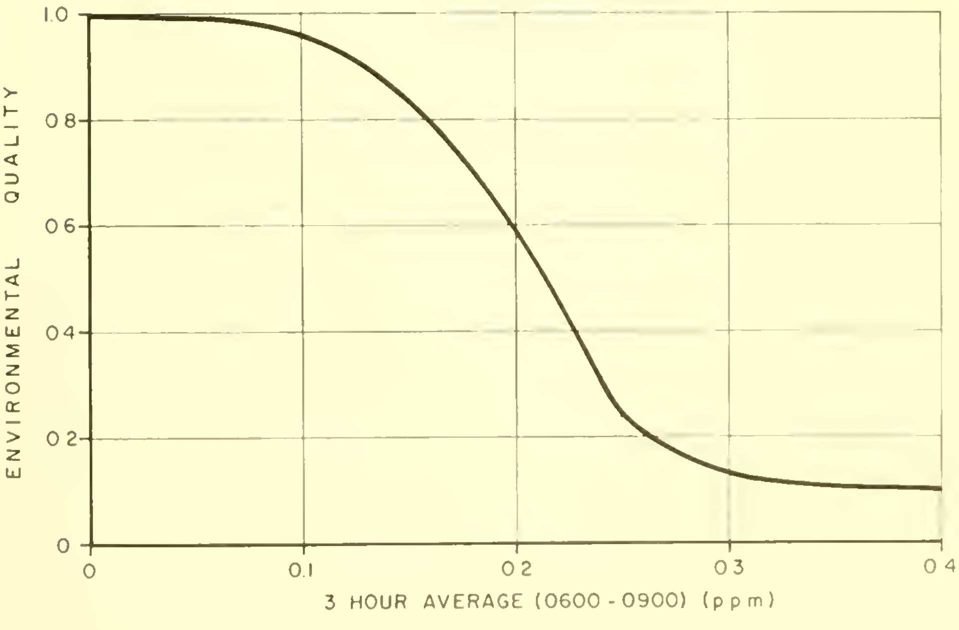


FIGURE 40. HYDROCARBONS

Nitrogen Oxides. Oxides of nitrogen, together with hydrocarbons, participate in photochemical reactions leading to the formation of photochemical smog. Nitric oxide (NO) forms during high temperature combustion as in automobile engines and large power plants. It then oxidizes to nitrogen dioxide (NO_2), which leads to smog formation.

The value function (Figure 41) for oxides of nitrogen should reflect the presence or absence of other smog constituents. For example, in the absence of hydrocarbons, relatively high concentrations of oxides of nitrogen would be innocuous. However, it can be assigned a value function of its own, based largely on published air quality criteria and standards.

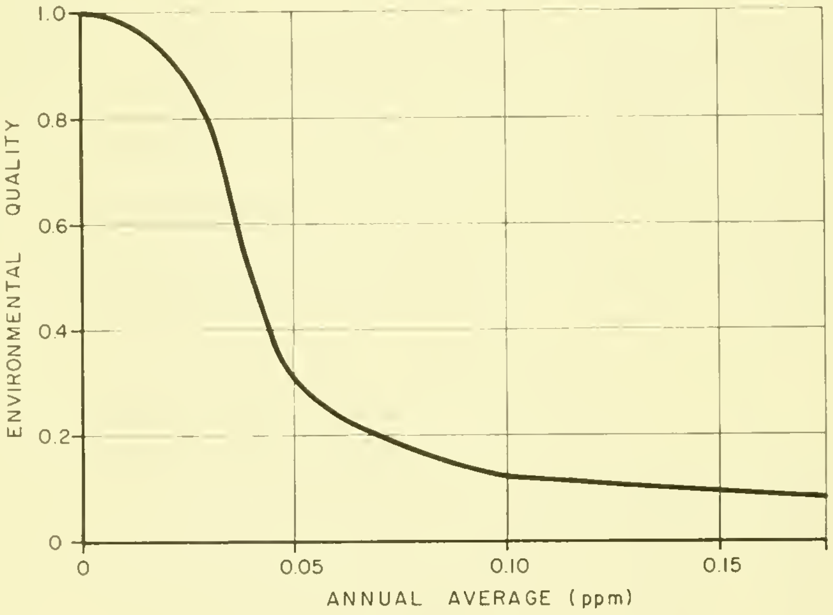


FIGURE 41. NITROGEN OXIDES

Particulate Matter. Suspended particulate matter, often referred to as "particulates" in the air pollution literature, is the most prevalent atmospheric pollutant. Even at remote locations uncontaminated by man, the cleanest air usually contains some hundreds of particles per cubic centimeter. Very polluted urban air may contain thousands of particles per cubic centimeter.

Most observations of "particulate" concentration are obtained with equipment which preferentially collects particles in the range 1 to 10 microns. Larger particles tend to settle out of the air due to gravity and are thus mostly a nuisance. Particles smaller than 1 micron, on the other hand, are most readily respirable and contribute the most to reduction of visibility due to their light scattering ability. In spite of that, most of the literature, criteria, and standards have reference to 1 to 10 micron particles, the concentration of which is expressed as mass per unit volume, usually micrograms per cubic meter.

A value function (Figure 42) for these particulates has been constructed giving consideration to established air quality standards and the criteria upon which the standards are based. In general the value function declines relatively steeply as concentrations become great enough to cause noticeable turbidity or to contribute to corrosion of materials. It will decline more slowly at higher concentrations where health effects begin to appear, but will certainly be very low at typical urban concentrations. The value function declines again as concentration approaches zero. That is because some particles are necessary to provide condensation nuclei upon which fog and cloud droplets can form.

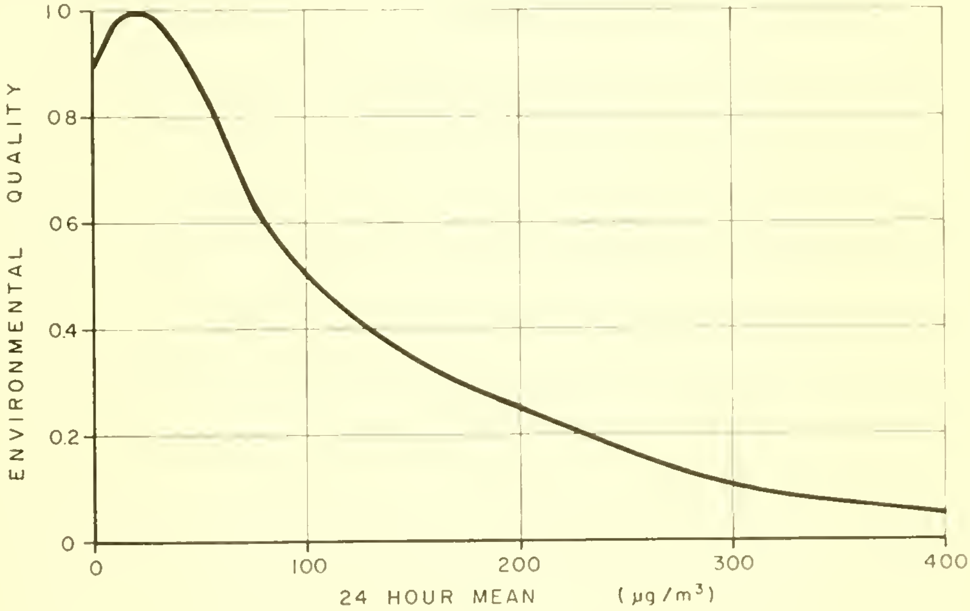


FIGURE 42. PARTICULATE MATTER

Photochemical Oxidants. Ozone is the principal one of the oxidizing gases being monitored and reported collectively as oxidants. Total oxidant content is, however, greater than the concentration of ozone. Some sensitive plants begin to show oxidant damage at relatively low concentrations, at which point the value function (Figure 43) can be expected to show an abrupt decline. As one of the constituents of photochemical smog, the oxidant value function will continue to decline fairly rapidly until the smog concentration is no longer noticeable, as on a smoggy day in a city such as Los Angeles.

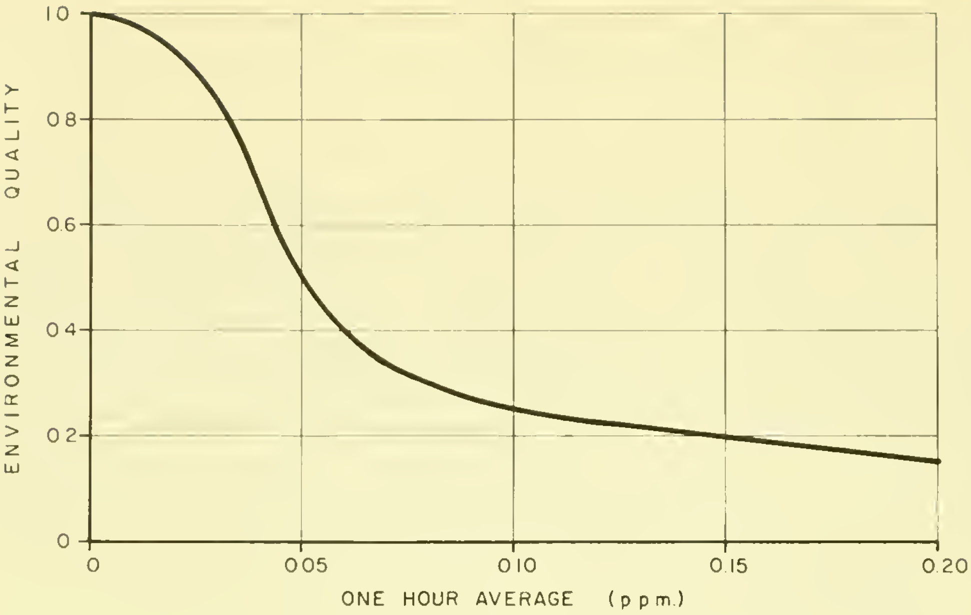


FIGURE 43. PHOTOCHEMICAL OXIDANTS

Sulfur Oxides. Sulfur dioxide is generally the only sulfur oxide considered, although it has a relatively short life. Ultimately, it contributes to the formation of sulphate particles or droplets of dilute sulfuric acid. It does, however, have deleterious effects as SO_2, and when it occurs in the presence of suspended particulate matter synergistic health effects are found.

Only at very high concentrations is it readily detectable by taste or smell; at very low concentrations there are no apparent effects. The value function (Figure 44) will decline rather abruptly as effects on plants, visibility, and corrosion of materials appear.

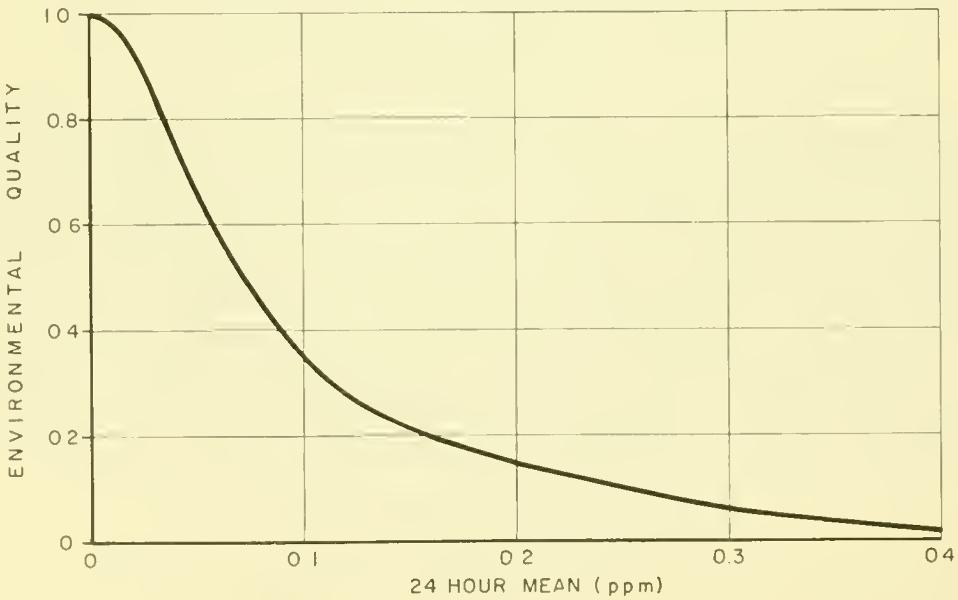


FIGURE 44. SULFUR OXIDES

At higher concentrations, as in many cities, the already low values of the value function will continue to decline, but relatively slowly until the concentration reaches very high levels.

Other. A category included to permit the handling of pollutants not covered in the above list. It is felt that this category is needed because of the wide spectrum of potential air pollutants from industrial sources that might result directly from Bureau supplied water.

Land Pollution

Land quality is not a conventionally discussed and measured aspect of environmental quality. Nevertheless, Bureau of Reclamation projects have definite impacts on project lands that must be reflected in any comprehensive environmental analysis.

Land in the western states is used by man for agricultural production, residential and industrial development, resource development, and open-space conservation. Each of these uses has, in some circumstances, been mismanaged and has contributed to an environmental pollution problem. The improper use of fertilizers and pesticides on farm land has in many cases affected the natural food chain and, through the natural runoff processes, the entire environment. Runoff itself has created environmental problems by increasing the erosion from construction areas and areas of low vegetation. Also, the lack of a "balanced" distribution of open and forested land in relation to residential, recreation, and industrial development has created environmental problems. Needed in a balanced land use system are zones of transition, i.e., buffer zones between different land uses, such as the use of undeveloped lands surrounding Bureau of Reclamation reservoirs. Land is also used for the disposal of man's solid waste. These wastes are generated as by-products of Bureau of Reclamation activities during construction and operation.

Battelle-Columbus believes that land related impacts of Bureau projects are of two major types. The first has to do with changes in land use that result as part of a project. The basic premise is that the development of incompatible land uses detracts from environmental quality; it is felt that land use evaluations can be restricted to conditions at the reservoir site. The second major way that Bureau projects can affect land quality is through erosion. Often if precautions are not taken during construction and subsequent operation of a project, increased soil erosion may result; a key factor governing the extent to which this will be a problem is the erosion potential of the lands involved as indicated by its sediment yield characteristics. On the other hand, Bureau activities may eliminate a soil erosion problem or have other beneficial impacts.

Land Use (Reservoir Site). Land in the United States is used for activities ranging from open space to industrial development. Because every land use is related in some way to all other land uses, its spatial distribution in an area is important; distribution determines whether adjacent land uses are complementary or competing. In planning for an area it is desirable to develop patterns of land use that are as compatible as possible.

Water resources in the West have been developed primarily for irrigation, water supply, recreation, and fish and wildlife. Land uses resulting from these and related activities have affected the environmental quality both adversely and beneficially. In the past a number of adverse impacts have occurred at or near a developed reservoir, primarily because uncontrolled land use was permitted at the reservoir which in turn led to high density development.

To reflect such impacts, land use was included as a parameter in the EES. For this analysis, all land uses have been grouped into two classes – undeveloped and developed land. It is felt that the undeveloped land has minimum impact on the environment and therefore has a high environmental quality. This class includes all land designated by either law or zoning control for recreation, as a preserve (timber, agriculture, wildlife) or open space. Service activities such as motels and restaurants are not included in this class. All other land is defined as developed.

The impact on the environment is not only a function of the class of land but also the density of development. It is assumed that the greater the density, the greater is the adverse impact on quality. Where more than one density occurs, an average estimate should be used in the analysis.

The value function (Figure 45) is based on percent of land developed in the area surrounding the reservoir and the intensity of this development. For consistency, the boundaries used in this parameter are the same as those used in the esthetic evaluation for a reservoir. These boundaries are from the edge of the existing river or developed reservoir to the ridge line (sky line) or to a point one-half mile in horizontal distance from the river/reservoir. The distance which is the minimum of these two would be selected for computation of the area.

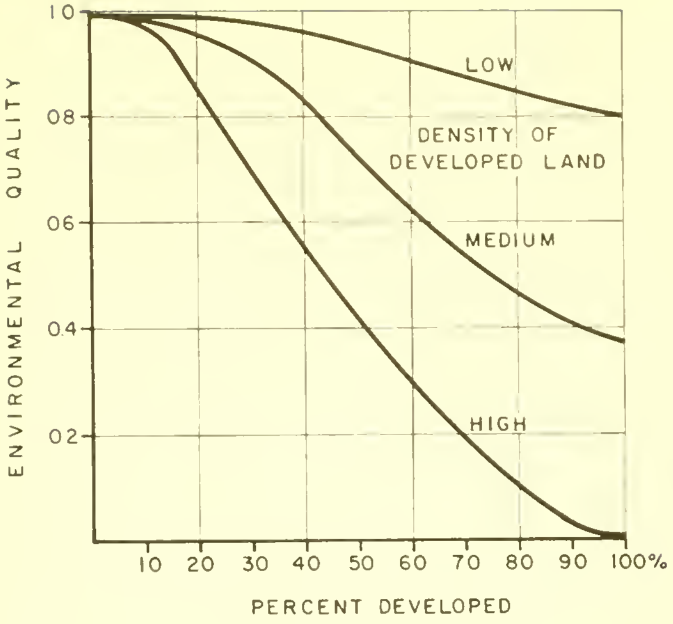


FIGURE 45. LAND USE

Soil Erosion. Soil erosion is another mechanism by which Bureau projects can affect overall environmental quality. Opportunities for increased erosion exist during construction phases and later if land use controls and other precautions are not exercised at the reservoir site. On the beneficial side, Bureau projects can help to decrease soil erosion through promoting the conversion of lands from dry farming to full service lands. Erosion is more of a problem on dry crop lands than on fully irrigated land because of the low density of vegetation on dry crop lands.

Soil erosion is a difficult parameter to quantify in aggregate. A convenient basis upon which to establish estimates is the sediment yield classification of the lands involved; the commonly employed classification is in terms of acre-feet/square mile/year. A value function (Figure 46) has been structured using standard sediment yield classifications along with the following associated descriptors:

Sediment Yield, acre-ft/sq mi/year	Descriptor
0	None
0.2	Negligible
0.5	Slight
1.0	Moderate
>3.0	Excessive

Impacts of Bureau activities are quantified first by determining the sediment yield characteristics of the lands involved and then determining any local changes that might result from the projected activity. For example, if a reservoir is to be built in an area characterized by slight sediment yield (or 0.5 acre-ft/sq mi/year) one might estimate that during construction, erosion might approach the moderate range, and that after construction, erosion at the site might approach a slight to moderate condition if unlimited land use is permitted to develop.

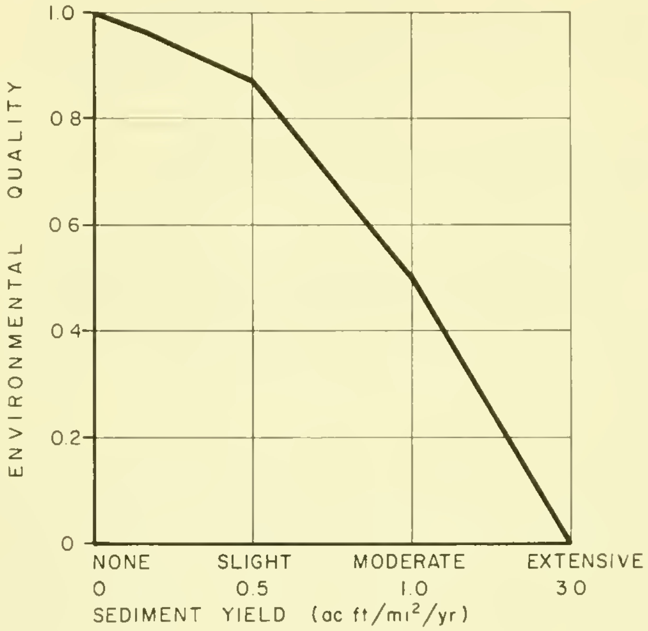


FIGURE 46. SOIL EROSION

Noise Pollution

Noise pollution has only recently come to be recognized as a pollutant — or more precisely as an environmental stressor. Although Bureau of Reclamation projects and related activities are only minor sources of noise pollution, noise is included as a parameter in the interest of comprehensiveness.

Noise is created both by man's activities and by natural phenomena. Noise may have a physiological effect, in which case it may be considered to be a pollutant, or a psychological effect, in which case it is more of an esthetic factor. For example, the singing of birds and the bubbling of a brook can be considered as desired sounds. In other cases, however, noise can cause damage to man and nature. Some examples of undesirable sounds are noise from the normal operation of project facilities, such as generators and machine shops, or as a result of man's use of reclamation projects, such as outboard motors and snowmobiles at recreation areas. The noise parameter is employed to evaluate these kinds of impacts of Bureau of Reclamation projects on noise pollution.

Bureau projects can be sources of minor noise in two primary ways. One means is by catalyzing the development of an area; this in turn will usually lead to additional vehicular noise especially at recreation sites, and in some cases to additional industrial noise (mining, ore processing, logging, etc.). The second aspect of Bureau projects that might create noise pollution is the construction operations – bulldozers, dump trucks, blasting operations, etc. In either case the main effect of such noise is likely to be some detraction from the wilderness/isolation atmosphere of an area. Noise levels due to Bureau projects are not likely to reach high disturbance levels.

In urban areas where noise is a major problem several parameters of noise are usually of interest including: intensity, frequency distribution, distribution of frequency and intensity throughout the day, variety of sound, and relationship between the sources of noise and the recipients of noise. To avoid the unwarranted complexity of handling these multiple parameters in the context of Bureau of Reclamation projects, two have been selected for incorporation into a noise value function. These are the intensity of noise and the frequency of occurrence and distribution within the project area. Intensity is represented by conventional decibel dB(A) units and by a subjective scale from "natural level" to "loud". Environmental quality is shown to decrease with both increasing intensity and increasing frequency and distribution (Figure 47).

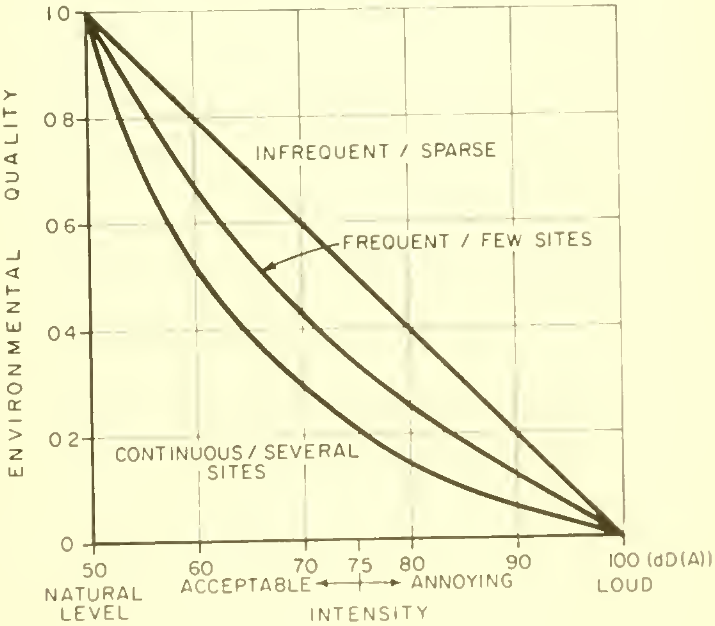


FIGURE 47. NOISE

Esthetics

Many interacting factors contribute to the total esthetic effect of a given geographical area. Some of these factors are not directly affected by the construction of Bureau of Reclamation projects. For example, the skies of Nevada and Arizona over the period of a year are generally more dramatic than those along the Cascade Range in Washington, where there is frequently rain and fog. Extreme hot and prolonged temperatures create an unfavorable esthetic quality. These factors help make up the comprehensive esthetic quality of a given geographical area, but are affected little if at all by Bureau activities.

Examples of direct factors that result from Bureau activities would be the creation of a reservoir, highway construction, alteration of a free flowing river, or the construction of a visitors center or a power station.

To a degree, personal opinion becomes involved in setting esthetic standards and evaluations. What may be extraordinarily pleasing or significant to one person may not stimulate a particularly favorable response from another person.

The forester may see a young brush forest well stocked with saplings and seedlings of valuable timber species as having high esthetic qualities. The city dweller on a Sunday hike probably would see little beauty in this site, but would be drawn to the over-age stand of tall trees instead.

Frank Lloyd Wright, famed architect, designed his now world-famous Fallingwater house over a beautiful waterfall in a forested Pennsylvania setting. The falls could not be viewed from the inside of the house. The explanation for his decision was that the suspense and interest generated by the sound of the falls would have been lost if it had been in view at all times.

Rock music as opposed to a Brahms symphony, an abstract painting compared to an Andrew Wyeth landscape, the colonial school or church compared to a structure designed with strong contemporary lines are a few more examples of areas where there would be a divergence in many minds regarding which was esthetically most satisfying.

Individuals vary in their responses to the external stimuli of the world in which they live. Psychological subtleties are deeply involved in their reactions. Thus, esthetics is an elusive quality difficult to define and almost impossible to measure.

By accounting for the various esthetic reactions that people have to the kinds of site areas where Bureau of Reclamation projects are located and the changes that Bureau projects may cause, relevant esthetics parameters were selected for the EES.

Relevance of Esthetics to Bureau of Reclamation Activities

The Bureau of Reclamation has been charged by the Congress with the serious task of water resource development in the 17 contiguous western states. Its objective is to provide multipurpose projects for irrigation, for industrial and municipal use, for hydroelectric power, for flood control, for recreation, for fish and wildlife protection and management, for water quality control, and other purposes.

Yet, in carrying out the mandate of Congress, the Bureau at times impounds large reservoirs which interrupt free-flowing streams and cover large acreages of land. Under certain circumstances, despite all normal safeguards by Bureau planners, the construction of these reservoirs may alter or destroy tangible and intangible values of extreme esthetic significance. When this happens, a strong public reaction can be anticipated.

Obviously, any construction is likely to destroy certain esthetic values, while at the same time creating new ones. The prime objective is to select sites where a balanced exchange of these values can be achieved, without destroying highly important and highly prized natural features of the environment.

In spite of the need for more water for domestic and industrial use, irrigation, hydroelectric power and recreation, the people of the United States have become increasingly conscious of the need to protect the natural environment and to preserve the unique and beautiful things in nature. Also, as population stresses increase, outdoor recreation has become increasingly important for the mental and emotional health of society as a whole.

Today, about 80 percent of the people of the United States live in urban or suburban communities. This crowding together, and the resultant stress of city life, are contributing factors in creating a huge demand for tension-relieving outdoor recreation. At the same time, shorter working hours and higher incomes have made it possible for more people to take advantage of recreation opportunities. The trend continues unabated. The new prosperity, high-speed highways, improved air travel, new and better equipment for outdoor living and an expansion of recreation sites and facilities have contributed to a major recreation "boom". If present predictions remain valid, this great swell of enthusiasm for outdoor recreation and an esthetically desirable environment will continue to rise at a rapid rate. It will be reinforced by the continuing urbanization of the American people and supported by a growing conviction of the medical profession that the relaxations and rewards of outdoor experiences are not only desirable, but almost imperative, to the health and well being of the populace.

In the past, the activities of the Bureau of Reclamation have been largely dictated by material and economic needs. However, in the context of the mental and emotional impact of late twentieth century living patterns in the United States, the esthetics and recreational aspects may now have reached a priority level with the more obvious economic objectives of the Bureau's projects.

As a result, the skillful and sensitive recognition and preservation of esthetics in the selection of project sites and in architectural design can be considered a matter of fundamental importance to society.

From the vast array of concerns that relate to the esthetic quality of a site, a project area, or a structure, six components of esthetic parameters have been designed into the EES. These components – land, air, water, biota, man-made objects, and composition – form the framework for judgmental yet, hopefully, objective comparisons of esthetic quality at sites "with" and "without" Bureau projects.

It should be noted that many esthetics parameters are concerned with aspects of the environment that are related to parameters in other categories. Thus, water is of concern as an esthetic entity as well as an important medium in both the ecology and environmental pollution categories. Biota is of principal concern in ecology, but also enters into the analysis in the human interest parameters in relation to areas of ecological significance. Esthetic parameters do not overlap the parameters in other categories because they reflect a different set of environmental values and indicators.

Land

The land on which Bureau of Reclamation projects are located plays a major role in determining the esthetic effects of project construction.

A reservoir situated on flatlands is scenically less attractive than one nestled in high mountains. However, the flooding of deep valleys or canyons may destroy scenic beauty already in existence. Thus, the act of flooding a mountain valley or canyon is likely to be rated negatively in respect to esthetics. Yet, the result of this flooding – the lake produced – will have a much higher esthetic rating than a lake of similar size created upon relatively flat lands.

Likewise, the nature of surface material adjacent to project structures may determine their overall esthetic impact.

Geologic Surface Material. The esthetic quality of land is enhanced by unusual coloration and diversity in the types and textures of its component materials.

Highly-colored rock, large areas of smooth rock or boulders, and pure sand are considered visually desirable where geologic surface material is not hidden by vegetation. (See Figure 48).

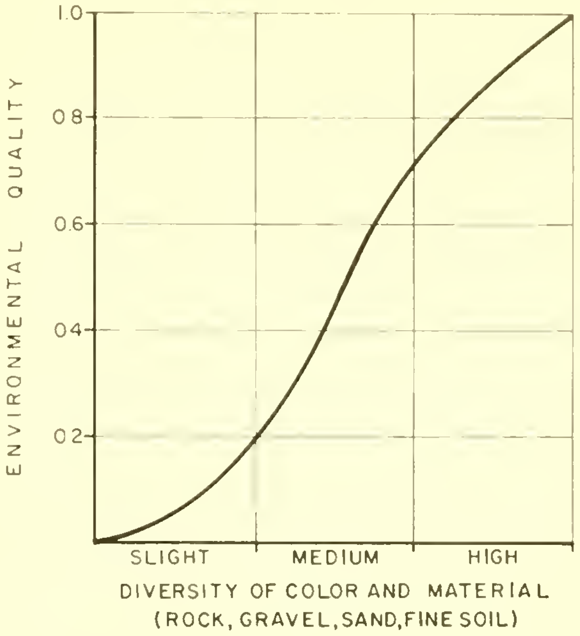


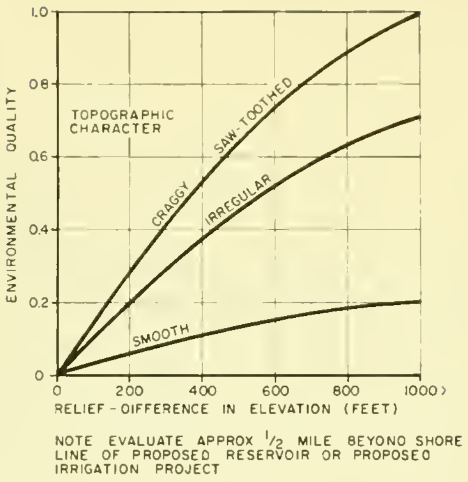
FIGURE 48. GEOLOGIC SURFACE MATERIAL

Painted Desert and Bryce Canyon are examples of places that would rate very high in this category, while an area of unvegetated fine soil or muck near a stream or reservoir would rate low.

Relief and Topographic Character. The esthetics of topography can be divided, for evaluation, into two factors: (1) the vertical difference between the highest and lowest points of land on the site to be rated and (2) the shape of the site's most salient topographic features. (See Figure 49).

Assuming, for the moment, that all other visual components of the landscape are equal, then the greater the vertical relief, the greater the scenic quality of a site. Mountains towering high above a valley floor or canyons cut deep below the surface are more visually stimulating than low hills or shallow valleys.

The character of the vertically oriented components of the landscape affects esthetic evaluation, too. Smooth landforms are rated on a low esthetic evaluation curve, while craggy, "saw-tooth" profiles are rated on the highest curve; varying degrees of ruggedness and irregularity are in between. On this particular parameter, for example, the Grand Tetons would rate higher than the Appalachians.



NOTE EVALUATE APPROX 1/2 MILE BEYOND SHORE LINE OF PROPOSED RESERVOIR OR PROPOSED IRRIGATION PROJECT

FIGURE 49. RELIEF AND TOPOGRAPHIC CHARACTER

Width and Alignment. The proportion of the width of a canyon or gorge to its depth (measured from the highest surrounding points to the valley floor) and the deviation of a watercourse from a straight line have a direct bearing on the esthetic quality of a deep valley or stream.

A valley is most visually exciting if its width is nearly equal to its depth, less so if its width is two or more times its depth. A stream or long and narrow reservoir is esthetically most pleasing if its path is tortuous, less so if it is gently meandering, and least of all if it approaches a straight line. These factors are measured against environmental quality in Figure 50.

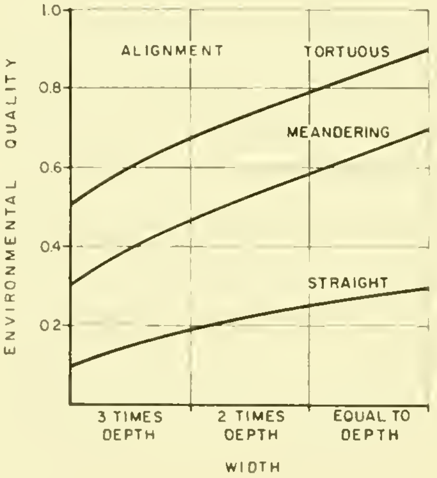


FIGURE 50. WIDTH AND ALIGNMENT

(Canyon and River Valley)

Air

Esthetics related to air are based, in part, upon the presence or absence of pollutants, the presence or absence of water vapor, turbulence and temperature. Air has maximum esthetic appeal when it is free of pollutants, low in humidity, moderate in temperature and relatively low in velocity. Air pollutants may offend by sight or smell, or both. Air with excessive water vapor intensifies both heat and cold and may cause respiratory distress even at comfortable temperatures.

Sounds both pleasant and unpleasant also influence the esthetics in an area. They are natural or man-made and occur at different frequencies. Those sounds which clash with the peace and solitude of nature are usually caused by human activites. "Sound" reflects the esthetic qualities of tone, whereas noise, included under the environmental pollution parameters, signifies intensity, duration, and distribution as measured in decibels.

Odor and Visual Quality. Polluted air is esthetically offensive in at least two ways: (1) it may carry disagreeable odors and (2) it may contain visible gases or suspended particles which render the vista dull and flat, or even practically invisible.

The odor and visual quality parameter must be rated very low if a disagreeable odor is present, while a lack of odor or a pleasant odor rates highest. The scent of evergreens, wildflowers, or wild herbs is a delightful asset to the esthetic quality of a site.

Frequent view-obscuring haze, dust, or smog earns a low rating while consistently crystal-clear air rates highest. Clean, bright air is increasingly sought after by town and city dwellers in their outdoor recreational and esthetic experiences as an end in itself, and so is very important in any visual considerations.

These considerations are expressed in Figure 51 by three curves. Measurement is qualitative in nature.

Sounds. Sounds are rate according to their pleasantness or unpleasantness, and their frequency. (See Figure 52.) Pleasant sounds include natural animal sounds like the songs of birds, the buzzing of cicadas, the haunting cries of the loon, the wails of coyotes and wolves, the peeps and croaks of frogs, and the clarion calls of wild geese. Other pleasant sounds might be produced by the wind as it rushes through evergreen trees or whistles through rock formations, and by water as it splashes over rocks or laps against a shore.

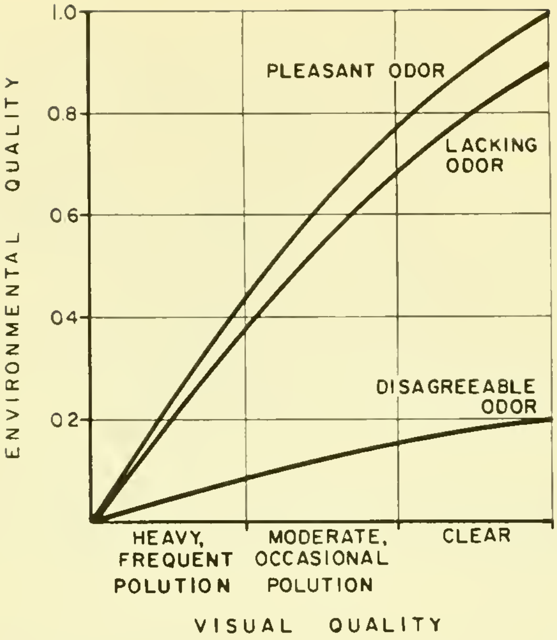


FIGURE 51. ODOR AND VISUAL QUALITY

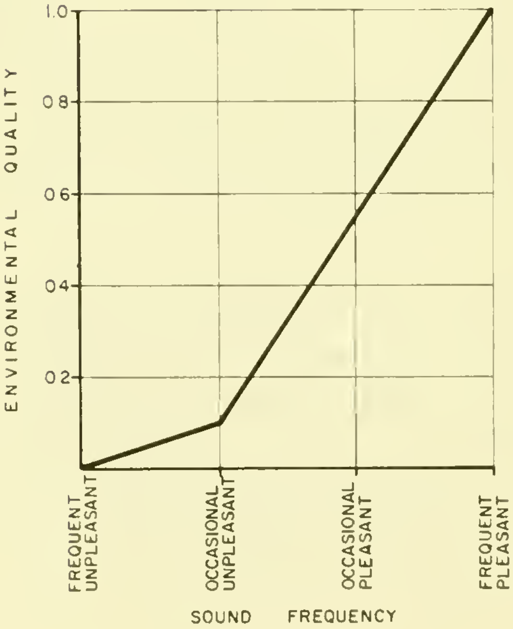


FIGURE 52. SOUNDS

Unpleasant sounds include the loud, discordant, and unnatural noises produced by industry, highway vehicles, railroads, airplanes, and other machines. These clash with the peace and solitude of nature, robbing recreationists of the very experience they may be seeking.

Water

Water is an extremely important component in the overall esthetic quality of a Bureau of Reclamation project site. The esthetics of a water body relate to the characteristics of the water body itself and to the characteristics of its interface with the adjacent land masses, i.e., shoreline characteristics.

Appearance of Water. The esthetic quality of water depends on its clarity and, in a stream, on its rate of movement. Pure, clear water is most desirable; fast-moving white water is considered more visually exciting than slow or static water.

Fast flow can do little to offset the esthetic drawbacks of turbidity or color. Silt and sediment, algae, visible dissolved minerals, and pollution can do severe damage to the visual quality of water.

The value function given in Figure 53 measures both the flow and quality in an esthetic framework. Qualitative measurements are used in the value function.

Land and Water Interface. The land-water interface caused by drawdown in a reservoir is a serious problem esthetically. The appearance of a shoreline can be radically altered for the worse by fluctuation of water level. Drawdown leaves man-made objects on the shore high and dry. Boat docks, beaches, and retaining walls become useless and unsightly. Reservoirs' mud bottoms are exposed, inhibiting approach to the water's edge and rock outcroppings show unnatural high water marks.

These considerations are evaluated by the value function given in Figure 54.

Odor and Floating Materials. Water that gives off an unpleasant odor or that carries excessive quantities of floating debris, oil, or scum is esthetically displeasing. It is recognized that certain mild, natural water odors, even though noticeable, are not always disagreeable and should be rated only slightly lower than no odor at all.

Both the degree of odor present and the extent of the detached floating materials are given in the value function shown in Figure 55. Three curves are used to express both considerations.

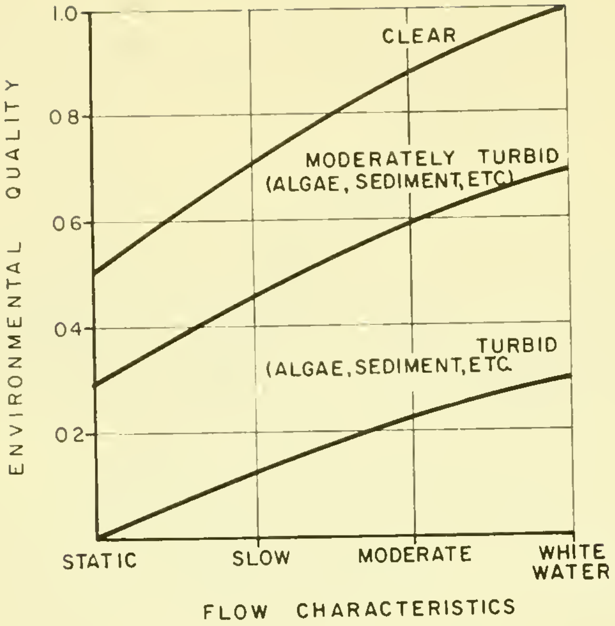


FIGURE 53. APPEARANCE OF WATER

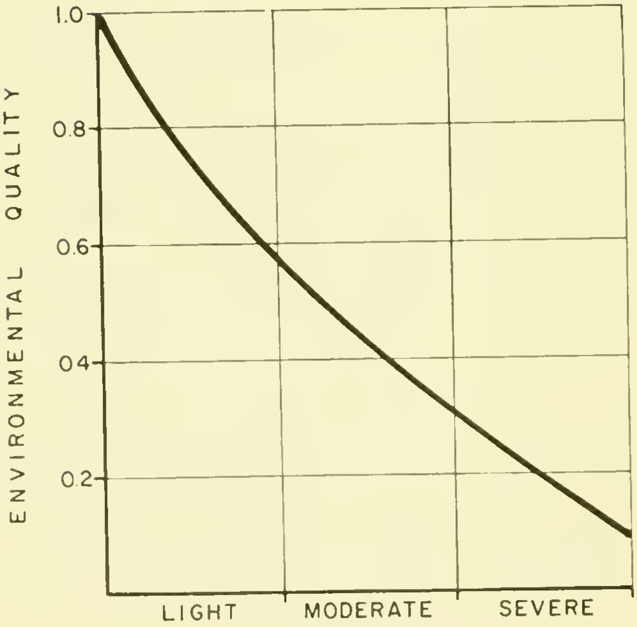


FIGURE 54. LAND AND WATER INTERFACE

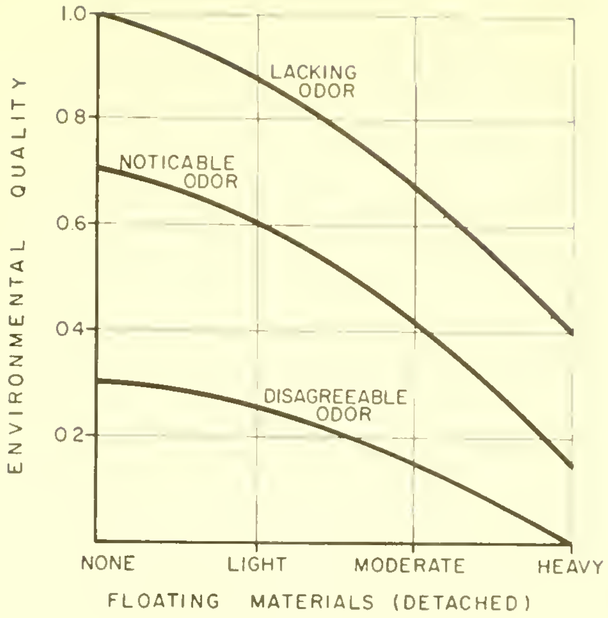


FIGURE 55. ODOR AND FLOATING MATERIALS

Water Surface Area. People seem to have an innate, natural affinity for water, and gravitate toward it in recreational situations. The reflection of clouds, mountains and trees on the placid surface of a reservoir, or the movement of boats on a lake all reinforce the pleasant esthetic response made possible by flat water surfaces.

In general up to a point, perhaps a mile wide, the greater a reservoir's width and surface area, the greater its esthetic and emotional impact. The width of a reservoir is used in the value function (Figure 56) to measure the esthetic quality of water surface area.

Wooded and Geologic Shoreline. Sand, gravel, and rock are the most visually pleasing geologic materials for the edge of a stream or lake, while unvegetated fine soil or mud usually detract from the scene. The presence and abundance of trees and shrubs near the shore provide a textured vertical element to define the shoreline, creating a more interesting interface between land and water.

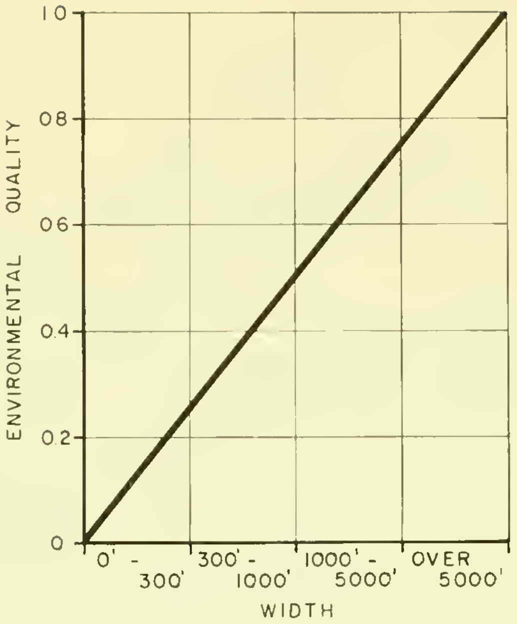


FIGURE 56. WATER SURFACE AREA

Both the wooded and the geologic aspects of the shoreline are measured in the value function given in Figure 57. Although percentages are stated, the percentage estimate for both the wooded and geologic should be judgmental in nature.

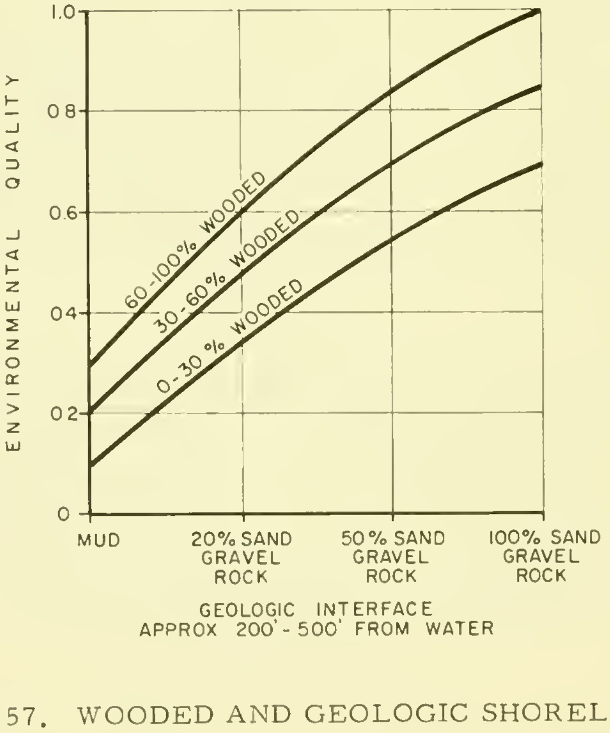


FIGURE 57. WOODED AND GEOLOGIC SHORELINE

Biota

Plants and animals, i.e., the composition of the natural ecosystem related to sites of Bureau projects, also have a profound effect upon the esthetics of project areas.

Although personal preference and prejudice are involved, certain types or species of vegetation are more attractive than others. A mixed hardwood-coniferous forest might provide the greatest contrast in color and form for the average eye. Yet, some people may prefer a pure stand of conifers, while others may prefer a stand of mixed hardwoods with no conifers. Most everyone prefers trees to lesser vegetation.

Flowering shrubs may have more eye-appeal than nonflowering species. Ferns may be more attractive than grass and one kind of grass may be greener than another kind. Thus, esthetic appeal is definitely related to vegetation type and species.

The presence of animals on lands surrounding a body of water have very positive esthetic values. The larger herbivorous animals (moose, elk, deer, etc.) would rate highest. However, smaller animals (squirrels, waterfowl, songbirds, etc.) could add measurably to the total esthetic value of the site.

Animals - Domestic. Domestic animals in a pastoral setting, particularly cattle and horses, are an asset to the esthetics of the landscape. Such animals give scale, movement, and life to a rural composition, but their overabundance adds little to a scene's visual quality, and may, because of overgrazing or odor, detract from it. For this reason the value function given in Figure 58 decreases in environmental quality as the abundance increases.

Animals - Wild. The presence of wild mammals and birds has a very strongly positive esthetic value. Large herbivorous mammals (moose, elk, deer, antelope, mountain goats and sheep) rate highest. Smaller mammals and all wild birds add immeasurably to the excitement of an area's sights and sounds.

Large carnivorous animals might have mixed esthetic values. For example, many people thrill at the sight of a grizzly bear, but it is possible that their fear of the animal might curtail their activity and reduce their overall enjoyment of an area. The known presence of mountain lions even though rarely seen, might have a similar effect.

The presence of rare or endangered species – California condor, bald eagle, mountain lion, or trumpeter swan, for example – is a prime esthetic asset and would doubtless provide the incentive for countless visitations to a site.

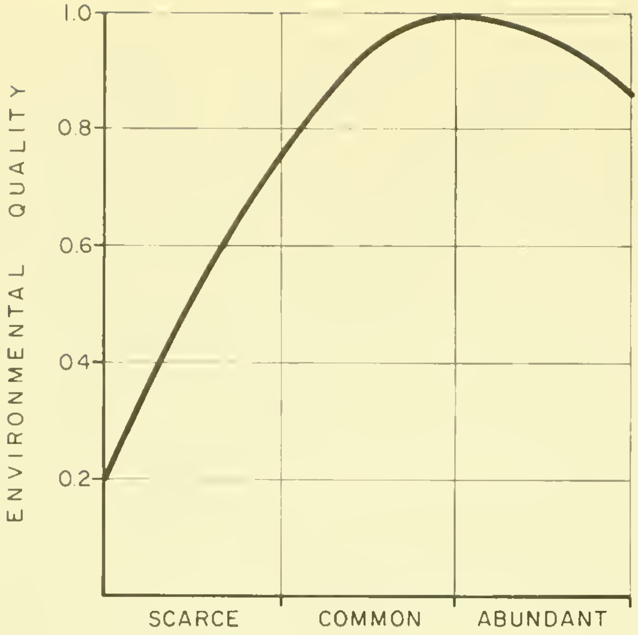


FIGURE 58. ANIMALS - DOMESTIC

Generally, the small, cold-blooded vertebrates are also esthetically pleasing elements of the water and land composition. Fish, particularly game fish, frogs and tadpoles, turtles, and lizards add movement, natural interest, and sometimes pleasant sounds to a site.

Some reptiles may have mixed esthetic values. Though many people enjoy sighting and identifying all wildlife including poisonous snakes, alligators, and the single species of poisonous lizards, precautions taken against the dangers of these animals may detract from visitors' enjoyment of a site.

The value function given in Figure 59 uses qualitative measures to express the environmental quality of both large and small wild animals.

Diversity of Vegetation Types. The esthetic quality of a site depends on its types of vegetation and on the proportions of the different types to one another.

Trees are considered the most visually pleasing vegetation type, and cultivated (irrigated) crops slightly less so. Low shrubs, grass, and dry farming are collectively rated somewhat lower than these, and the absence of vegetation is considered the least pleasing. Diversity rather than uniformity is desirable; land predominantly in trees, for example, but with a mixture of vegetation types, is rated higher than land with a 100 percent tree cover.

To rate a particular site on diversity of vegetation types, only one of the four sections of the value function (Figure 60) is used. The evaluator chooses the one

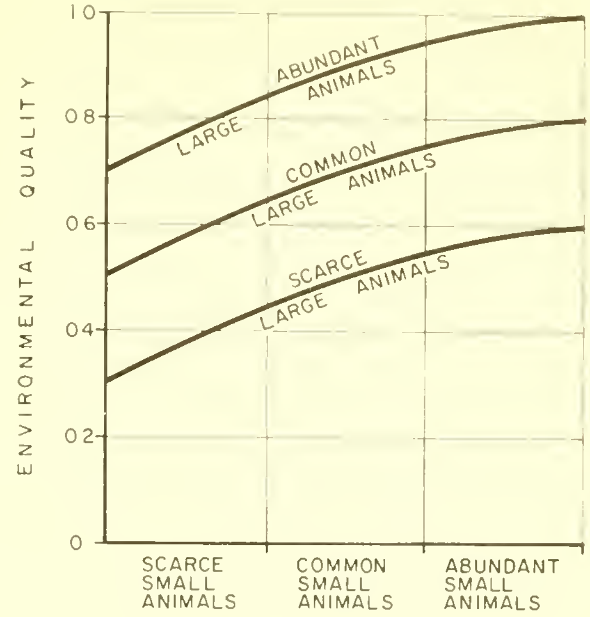
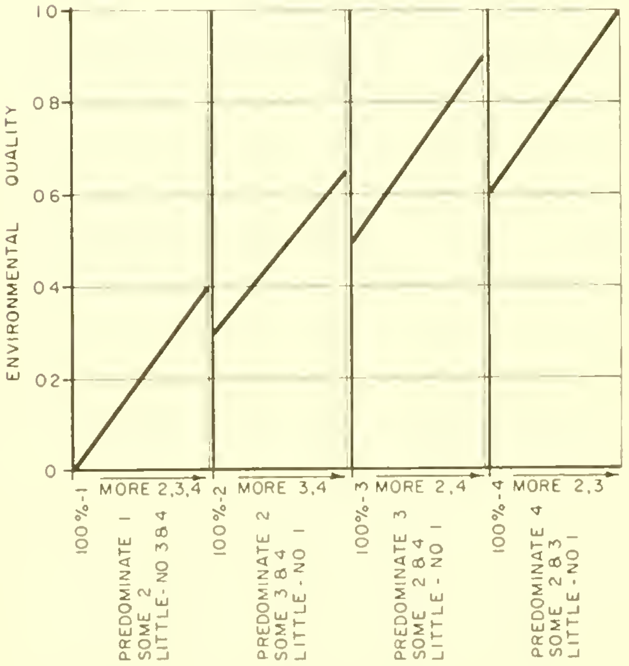


FIGURE 59. ANIMALS – WILD



NOTE
- EVALUATE TO APPROX 1/2 MILE HORIZ BEYOND SHORE LINE OF PROPOSED RESERVOIR
- WHERE TYPES ARE EQUAL AND THERE IS NO PREDOMINANCE, USE HIGHEST CATEGORY
- PREDOMINATING VARIETY
  - TYPE 1 NO VEGETATION
  - TYPE 2 LOW SHRUBS, GRASS, DRY FARMING
  - TYPE 3 CULTIVATED (IRRIGATED) CROPS
  - TYPE 4 TREES

FIGURE 60. DIVERSITY OF VEGETATION TYPES

labeled with the type of vegetation that, in his judgment, predominates on the site. For example, if the plant cover is 45 percent low shrubs, grass, or dry farming, 35 percent trees, and 20 percent unvegetated, the curve corresponding to vegetation type 2 is used. (Percentages should be estimated.)

If two or more vegetation types on the land to be evaluated are equally distributed, the curve corresponding to the highest category of plant material present is used. In other words, if the plant cover were one-third grass, say, and one-third both trees and cultivated crops, then the type 4 curve would apply.

The proportion of vegetation types on the site, other than the predominating type, is then determined. Where different types are interspersed on the same area of land, this calls for careful judgment. The greater the amount of vegetation other than that of the predominating type, the higher the rating.

Here again, judgment must be exercised. For example, if cultivated crops predominate on a site and trees cover the remaining land, the site should be given a higher rating than an area where cultivated crops predominate and the rest is in grass or dry farming. The evaluator should take into account the different values of the nonpredominating vegetation types.

Variety Within Vegetation Types. The greater the variety among species of plants within a vegetation type, the more visually appealing a site is likely to be. Especially attractive unusual or rare species of plants greatly enhance the esthetic interest and appeal of an area.

A mixed forest of both deciduous and coniferous trees is usually more colorful and esthetically interesting than a forest consisting of only one or the other. In a more arid ecological system, mixed varieties of desert shrubs and cacti are more visually exciting than a uniform cover of just one or two species.

Vividly colored flowering or leaf-dropping plants are especially delightful to the eye. Although seasonal, they must be considered an important visual component of the landscape.

Rare and unusual plants are valued so highly that many are protected in Federal, state, and community nature reserves; three better known examples are Sierra redwoods, saguaros, and joshua trees. Sites where unusual or particularly attractive plants grow in association with few other plant species, may merit as high an evaluation as areas with especially diverse vegetation.

The value function used to measure variety of vegetation is qualitative in nature. It is given in Figure 61.

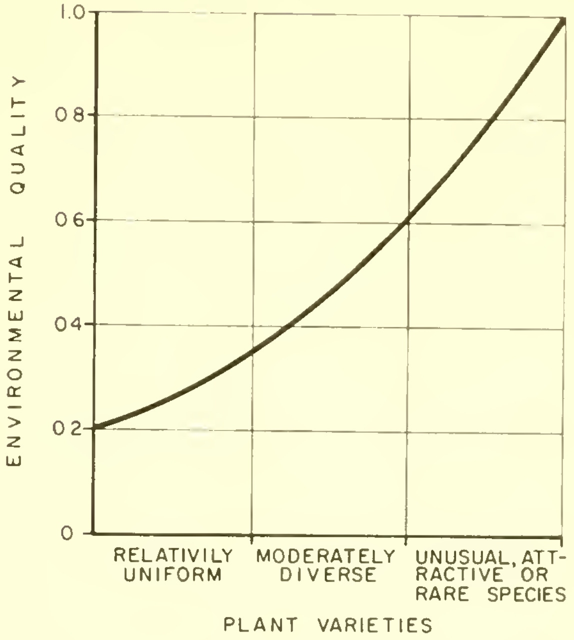


FIGURE 61. VARIETY WITHIN VEGETATION TYPES

Man-Made Objects

The esthetic quality of structures built by the Bureau of Reclamation depends to a large extent on their degree of consonance with the natural environment. A man-made object is considered to be consonant if it is harmonious or a subordinate to nature. This is determined by location, design, size, color and texture.

Such structures as utility buildings, highways, transmission lines, information centers, and small dams should be kept subordinate to the natural setting. Transmission lines, for example, should be kept out of sight if possible by screening them with vegetation and keeping their silhouettes off the skyline.

Small and medium-sized earth dams are sometimes scrupulously kept clear of all vegetation. Thin bare, straight lines are often irritating notes in an otherwise pleasing natural landscape. These dams should be covered with uneven layers of soil where native trees, shrubs, and grass would be permitted to grow, in cases where vegetation would not interfere with proper functioning or cause structural damage.

Buildings like pump houses, sewer treatment plants, and power stations should be placed where their presence least affects the esthetic quality of a site. Where the location of a visitor center or interpretive facility is determined by an overlook or some other scenic spot, the building is often conspicuous, and so should have an especially harmonious design, texture, and profile. Western scenery often has great sweep and conveys a sense of vastness. Here structures with low, horizontal profiles are preferable to those buildings which try to compete with the natural setting.

Monumental structures like major dams and bridges cannot be subordinate to their natural settings, but still may function in harmony with them. A structure of large proportions may be given a high esthetic rating on this parameter, but only if its design reflects and complements its surroundings, as in the Grand Coolee and Hoover dams. Color, texture, and configuration in this case determine consonance with nature.

Besides quality of design and construction, density is another factor that is vital to the visual quality of man-made objects. A small number of well-designed structures may not detract appreciably from an attractive landscape. But if the density of man-made objects were to increase, the natural esthetic quality of a scene would decrease and would then be rated lower on this parameter.

The value function given in Figure 62 measures both the quality of construction and the density of structures. As is stated in the value function it is possible to have structures that add to the total environmental quality of an area.

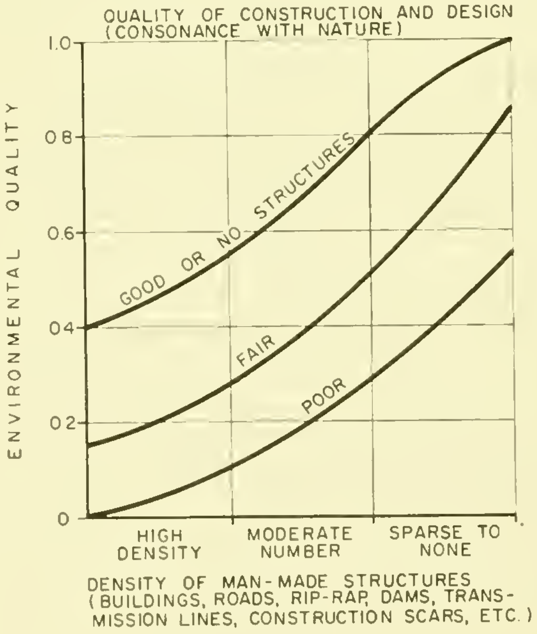


FIGURE 62. MAN-MADE OBJECTS

Composition

The composition of an area includes two considerations (1) the total esthetic picture and (2) scarce physical and biological assets in that picture. The total picture, composite effect, describes the combination of all elements that make a place look like it does. It is a completely subjective evaluation based on a response to the total esthetic character of a site.

Certain elements of the overall picture are also important. These elements are essentially "rare and endangered" esthetics which might change the entire picture drastically. Unique composition is used to guard against losing these treasures.

Composite Effect. The effect of the composite upon the senses and feelings of the observer is one of the most vital of all esthetic considerations. Anything beautiful, whether it be a flower, a painting, a symphony, or a human figure, is far greater than the sum of its parts. Probably nowhere is this more true than in the complexity of a natural scene or landscape. No matter how finely detailed an esthetic dissection, analysis, and evaluation may be, the observer's response to the total picture, to the interaction of all the major and minor components of the scene, must be weighted heavily.

The interplay of land, air, water, biota, and man-made objects can range from visually displeasing to spectacular. A low evaluation might be given a site in which inappropriate architecture distracts the eye from particularly beautiful rock formations, or to flat land with monotonous gray surface material and vegetation. A pleasant juxtaposition of farmland and forest might merit a medium rating. A high evaluation would go to a great rocky chasm with sparkling white-water at its bottom, or to jagged, snow-capped mountains reflected in a clear lake, or to a splashing waterfall in a forest of giant evergreens.

This value function is given in Figure 63. Because it was felt that no total picture had zero environmental quality the curve begins at 0.2.

Unique Composition. Another important consideration of the esthetic composition of any site is the scarcity and vulnerability of its particular physical and biological assets. These might be called "rare and endangered natural areas". The more unusual the composition to its region, the more esthetically desirable and valuable the site.

Utterly unique compositions are highest in value. Any man-made alterations to them would probably do irreparable harm and amount to an irretrievable loss to humanity. Clear-cutting the coast redwood forests, draining the Everglades, or damming the

Grand Canyon or the Yosemite Valley are examples of projects that have been proposed or partially undertaken that would destroy unique natural areas. Careful investigation and thought must be given each site of high overall esthetic quality to determine the effect of a proposed development.

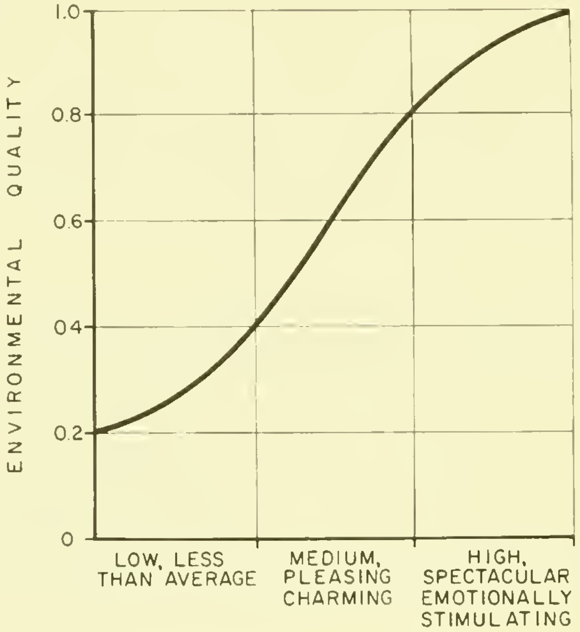
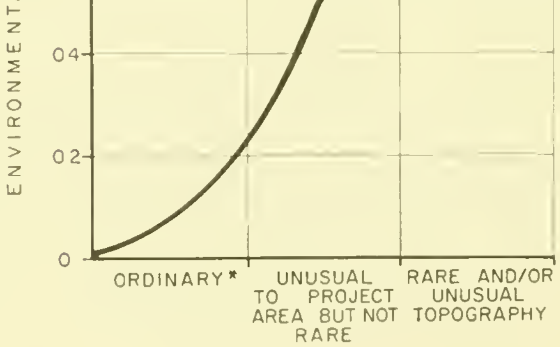


FIGURE 63. COMPOSITE EFFECT

In assessing this value function, Figure 64, the unique areas are singled out and evaluated. If there are none this parameter is not evaluated.



* RESULT IF AREA IS ALTERED BY PROJECT

FIGURE 64. UNIQUE COMPOSITION

Human Interest

Human interest aspects of the environment are those aspects which provide something beyond the absolute necessities for human life; they affect people's emotional lives; they add to the enjoyment of life.

Recent trends in education, leisure time, and per capita income indicate that there will be even more demand for sites where people can go to enjoy the natural environment, places of educational, historical, or cultural interest, and places that have special outdoor atmosphere or moods.

Also included in Human Interest are several parameters which are concerned with showing impacts that occur to people in the project area whose lives are changed as a direct result of the project. It is felt that these people should be considered a part of the environment in a project evaluation procedure.

Five major human interest components have been identified. They are

(1) Educational/Scientific Packages

(2) Historical Packages

(3) Cultures

(4) Mood/Atmosphere

(5) Life Patterns.

Educational/Scientific Packages

Parameters of the component Educational/Scientific Packages bring attention to sites or objects which are of some educational or scientific value. Included in these parameters are sites which serve as examples of natural processes, thus being of value educationally and scientifically. Specifically included in the parameters are sites or objects which are of unusual or significant geological, ecological, archeological, or hydrological interest to people. Such sites may also have historic value, but they differ from sites of historic significance in that their primary value lies in the fact that they teach people something – how the earth's processes work now, or have worked in the past, how prehistoric people lived, what kinds of prehistoric animals lived, etc.

Concept of "Package". The measurement of each parameter in the Educational/ Scientific component is closely tied to the use of a concept that Battelle-Columbus refers to as "the package concept". For example, within a project area, there may be several things of archeological interest. Everything of archeological interest that occurs in that area is thought of as one "package". Each occurrence, in and of itself, is not given a "with-without" evaluation. The "package" itself is given a "with-without" evaluation.

The procedure of identifying parameters that are relevant to a particular project evaluation involves the following steps for each individual parameter:

(1) Identify all occurrences within the project area that apply to this parameter.

(2) Think of all the occurrences totally as a package.

(3) Determine whether or not this total "package" is of any significance.

(4) (a) If it is determined that the package does have significance, refer to the value function to make a "with-without" evaluation of the package.

 (b) If it is determined that the package does not have significance, it will not be included in the evaluation.

In steps (3) and (4), the word "significance" is of utmost importance to the evaluation procedure and the proper use of the value function. Battelle-Columbus uses two more concepts to clarify the meaning of significance. These are the terms "internal" and "external". These terms help to identify the people to whom the package has significance. "Internal" refers to people who have been identified in the proposed project plan as being somehow affected by the proposed project – either beneficially or adversely – in one or more of its sectors. Thus, a package of "internal significance" refers to a package of occurrences of archeological (or geological, ecological, or hydrological) interest to those people who are identified by the Bureau of Reclamation as being directly affected by the proposed project. "External" refers to all other people outside of the project area who may have an interest in the effects or impacts caused by the proposed project. These two terms do not necessarily have a particular geographical connotation or boundary, although in some projects they may.

Therefore, before the value function can be used, the question must be asked – "Do the occurrences identified as being a part of this package have significance only to people in the project area, or do they have significance to people outside of the project area?" If the answer to the first part of the question is yes, then the package is an "internal package" and the appropriate value function is applied. If the second part of the question is answered by yes, the package is considered an "external package" and the appropriate function should be used. If the package has aspects of both internal and external significance, it should be considered an "external package".

Value Function for All Educational/Scientific Parameters (Internal and External). A combination of two value functions is used to measure all four parameters in the Educational/Scientific component. Because the inclusion of educational/scientific factors of the environment is a relatively new concept in the evaluation of the environment, literature references serving as sources for background information are extremely limited. Accepted means of measuring such factors and the impacts caused to such factors by changes in the environment are even more limited. Therefore, the design of this function was based on experience gained from this study. It is anticipated that, as use of the function indicates need for modification of the function, it should be amended accordingly.

There are five "quality descriptors" used in the internal value function (see Figure 65) to describe the quality or significance of a package:

(a) High
(b) High-Medium
(c) Low-Medium
(d) Low
(e) None.

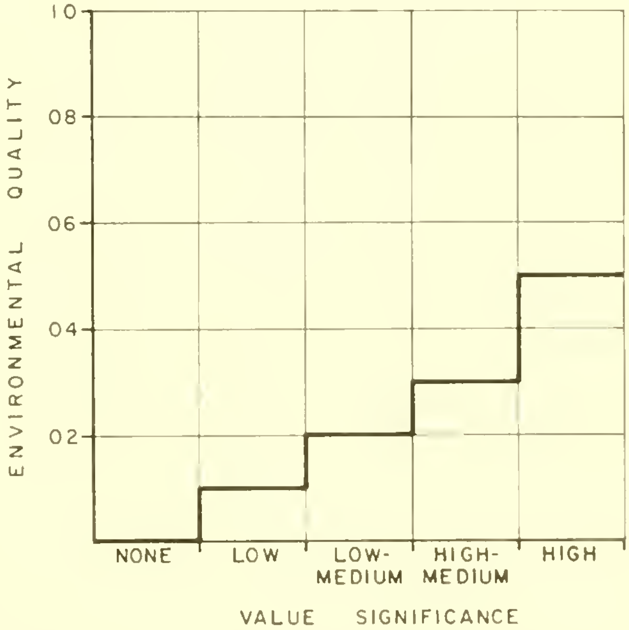


FIGURE 65. EDUCATIONAL/SCIENTIFIC INTERNAL PACKAGES

All refer to the value or significance of, and/or the interest expressed in the package by people defined as being "internal". The quality of the package can be rated as "High" to "Low". In making a "without" evaluation of the archeological package, the value of the package is determined by considering the value of each component of the package considered in light of each of the other package components. In the "with" evaluation, the value of the package is determined by considering the change occurring to all other components of the package.

The bases for determing the value (High, High-Medium, Low-Medium, and Low) of the package are

(1) The number of people visiting or using the components of the package

(2) The intensity of interest shown by those people making use of it

(3) The intensity of objections expressed by people if change to the package or a part of the package is indicated

(4) The value placed on the package by an expert in the field (e.g., archeologist, ecologist, or a geologist).

The descriptor "None" is used to identify a package which no longer has significance or value either because it no longer exists (e.g., inundation by the reservoir) or because of a high degree of adverse effects caused by a "with" situation.

The external package value function (see Figure 66) was designed in such a way as to give more value to a package that has "external" significance. This was done because it was felt that external significance indicated that something was of more importance to more people; therefore, should have more value. The quality descriptors used for the external package value function are the same as for the internal package value function, i.e., High, High-Medium, Low-Medium, Low, and None. The terms are the same, but their value is higher.

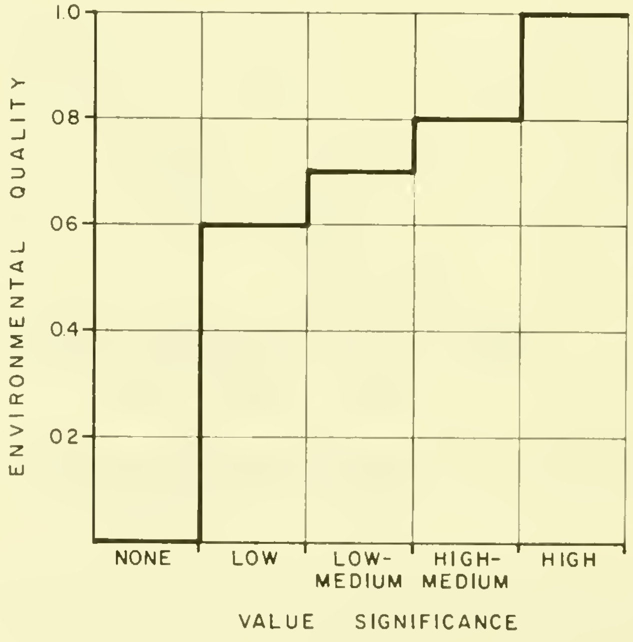


FIGURE 66. EDUCATIONAL/SCIENTIFIC EXTERNAL PACKAGES

In making a "without" evaluation of the archeological package the value of the package is determined by considering the value of each component of the package considered in light of each of the other package components. In the "with" evaluation, the value of the package is determined by considering the change occurring to each component in comparison with, or in light of, the change occurring to all other components of the package.

The basis for determining the value of an external package is the same as those used in evaluating an internal package.

Archeological. The archeological package includes anything which is demonstrative of the prehistoric past in the human life and cultural activities of a people. Mention should be made of the fact that, for the EES, archeological denotes mainly prehistoric times – prehistoric being defined as "of times antedating written history". Examples of what might be included in an archeological package are prehistoric villages, dwellings, objects used in everyday life activities, and remains of plants or bones of animals which may have become petrified.

Ecological. An ecological package involves aspects of the environment that educationally demonstrate interrelationships between organisms and their environment. This parameter was chosen because there has been an apparent trend of increasing interest in ecological processes, thus, also creating an interest in the places that support such processes. For example, the package may include a land or aquatic habitat of a vanishing or rare species of plant or animal that is, or could be, used for educational illustration. An example of a type of user is school science classes. Other sites of educational/scientific ecological interest include wildlife refuges (either natural or man-made), and unique forests and deserts (identified as being unique illustrations of ecological processes).

Geological. The geological package includes aspects of the environment which add significantly to the knowledge of the history of the earth and its life as is recorded in rocks and rock structures, and geologic phenomena which serve to illustrate unusual geologic processes. This history may be found in rocks and rock structures. Other examples that may apply to this package are sand dunes, meteor impact sites, and the works of volcanoes and glaciers.

Hydrological. The hydrological package includes unusual or unique water phenomena. Types of phenomena included in this parameter are geysers, hot springs, mineral springs, waterfalls, and lakes of unusual properties.

Historical Packages

Parameters bringing attention to things having historical interest have been added to the Human Interest category of the EES because (1) Bureau of Reclamation projects affect the western half of the United States where there are many things of historical interest remaining unchanged from the times the West was being settled and (2) People of the U. S. are more affluent and have more free time than ever before; these conditions have resulted in more people traveling, and as a part of their travels showing more interest in historical places.

Legislative action has recently begun to give recognition and protection to places of historical interest. The Historic Sites Act of 1935 established a "national policy to preserve for public use historic sites, buildings, and objects of national significance for the inspiration and benefit of the people of the United States". In 1966 the Historic Preservation Act expanded the preservation concept to include places of state and local, as well as national significance. This Act authorized the Secretary of Interior to expand and maintain a national register of places significant to American history, architecture, archeology, and culture. It established a 17-member National Advisory Council on Historic Preservation to advise the President and Congress and to coordinate preservation activities on Federal, state, and local levels. This Act also required any Federal agency planning a project to report to the Council the effect the project might have on sites listed in the National Register.

Places of historic value are those which have been the location of events of significant importance in the history of the United States. United States history includes recent Indian History (last 200 years), the history of the settlement of the "Western Frontier", and the development of the western part of the country. (Factors related to prehistoric Indians and their cultures are included under "Archeological" in "Educational/Scientific Packages".) Things having historic value can be sites, objects, or structures. Things having historic value will be included in at least one of five parameters:

(1) Architecture and Styles

(2) Events

(3) Persons

(4) Religions and Cultures

(5) "Western Frontier".

"Concept of Package". The concept of "package" for the Historical Packages component is precisely the same as the concept used for the Educational/Scientific Packages component. For a description of this concept, please see the preceding section — Educational/Scientific Packages.

Value Function for All Historical Parameters. The explanation for the value function for all Historical parameters is the same as for the Educational/Scientific parameters. Please see the preceding section for a complete description. See Figures 67 and 68 for internal and external packages.

Architecture and Styles. Structures, sites, and objects may serve as unusual examples of certain periods, styles, or methods of construction of historical value. Certain structures may be significant because they are representative of the work of an important master builder, designer, or architect. In determining the significance or value of such structures, sites, and objects, the following should be taken into consideration: location, design, setting, materials, workmanship, feeling, and association.

Events. Certain sites, structures, and objects depict or are associated with significant events in the history of the United States. Such events might be important because of the influence they played in the pattern of development in the United States. Examples of such events are battlefields, birthplaces, graves, and locations of significant discoveries. These may vary considerably, especially in local or "internal" interests.

Persons. There are many persons who are considered to have been of great importance in the history of the United States. This parameter includes significant sites, structures, and objects associated with the lives, careers, and activities of such people.

Religions and Cultures. Sites, objects, and structures of historical significance related to religions and cultures are those that have been important in the past and are not used in present times as a part of the practice of a religion or culture. Examples are Indian burial grounds, areas of religious importance to Indian tribes of the past, church buildings, missions, cemeteries, etc.

"Western Frontier". The history of the states included in the Bureau of Reclamation water development projects uniquely represents an era in the country associated with the Western Frontier. This includes places which are not related to a specific event,

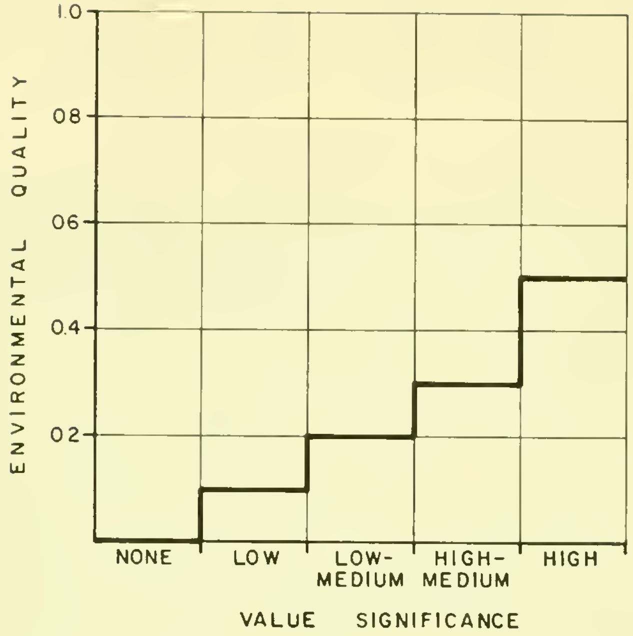


FIGURE 67. HISTORICAL INTERNAL PACKAGES

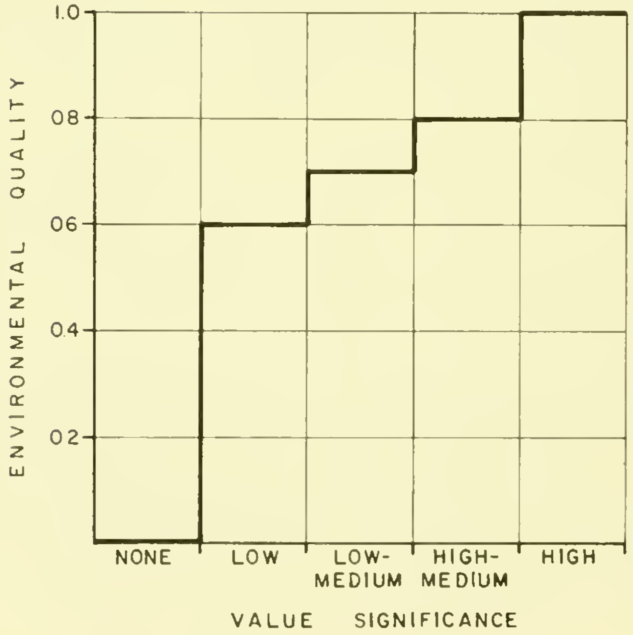


FIGURE 68. HISTORICAL EXTERNAL PACKAGES

person, or religion or culture of historic significance, but are still important to this period of history. Two examples are mining towns and pioneer trails.

Cultures

Factors of cultural importance are defined (for the EES) as those places, objects, and structures that are important to the present-day activities of subcultures existing in this country. They are important and of value, not because of their educational or historic value, but because they are presently a significant part of people's lives. A disruption to these factors would result in a significant change to the cultural practices of a people.

There are a large number of Indian tribes in the 17 western states of Bureau of Reclamation jurisdiction. Some of the tribes have structures and areas of land that are particularly important to their daily activities and religious beliefs. Such areas may not have significance to the majority of American people, but may be extremely important to a small minority of people. Because such people are a minority and they are often ill-represented, special mention must be made of situations where a proposed project may affect a people in these ways. The same type of situation may occur with other ethnic groups and religious groups.

The value function (see Figure 69) for the parameters under Cultures has three major categories of quality descriptors: (1) Existing, (2) Improved, and (3) Disruption to Existing.

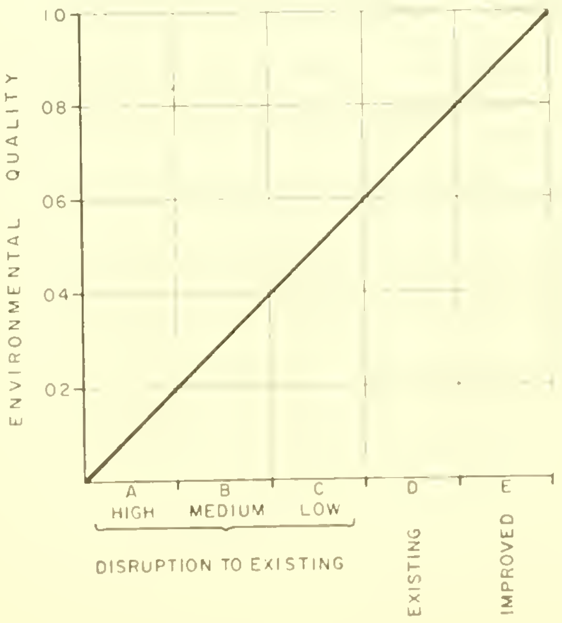


FIGURE 69. CULTURES

"Existing" refers to the present cultural practices and activities of a people. "Existing" may be assigned a value from .6 to .8 depending upon the level of complexity or development of the cultural activities.

"Improved" refers to any improvement that might occur to the culture. This would have to be evaluated by or at least with the aid of, the group affected.

"Disruption to Existing" refers to any disruption occurring to the cultural activities of a minority group. Disruption is further defined in the value function by "High" (a), "Medium" (b), and "Low" (c). This, too, would be evaluated better with the assistance of the group affected.

Indians. Each proposed project should be reviewed to determine if it will either adversely or beneficially affect the cultural practice of any Indian tribe. If it will, a "with-without" evaluation must be made, using the value function to indicate the importance of the effects to the tribe.

Other Ethnic Groups. Each proposed project should be reviewed to determine if it will either adversely or beneficially affect the cultural practices of any other ethnic groups (e.g., people of Mexican-American or Japanese-American descent). If it will, a "with-without" evaluation must be made, using the value function to indicate the importance of the effects to the ethnic group.

Religious Groups. Each proposed project should be reviewed to determine if it will either adversely or beneficially affect the activities or practices of any religious groups. If it will, a "with-without" evaluation must be made, using the value function to indicate the importance of the effects to the religious group.

Mood/Atmosphere

The component Mood/Atmosphere refers to the capacity an area has to produce certain feelings in people toward that area. A place with Mood/Atmosphere value in its present form or state (be it natural or not) is important to people because it creates a mood which is noticeably different from the mood created by a similar place. The places are uniquely distinguishable because of the moods or atmosphere created by them. The value placed on "wilderness" is representative of the type of significance described as mood or atmosphere.

The four parameters in Mood/Atmosphere describe four feelings or reactions on which people seem to place high value. The value placed on these feelings varies from individual to individual, and is extremely difficult to measure.

The value function (see Figure 70) is the same for all four parameters in Mood/Atmosphere — a straight linear function. The three quality descriptors are: Low, Medium, and High. To utilize the value function, the quality of mood/atmosphere (or Awe-Inspiration, Isolation/Solitude, Mystery, or "Oneness" with Nature) of a place should be ranked on a scale of 0 to 10: Low being 0 to 3, Medium 3 to 7, and High 7 to 10. The ranking of a parameter (e.g., Awe-Inspiration) might be done more easily by breaking down each descriptor further into low, medium, and high. Thus, the descriptor Low could be thought of as Low-Low, Medium-Low, and High-Low, etc.

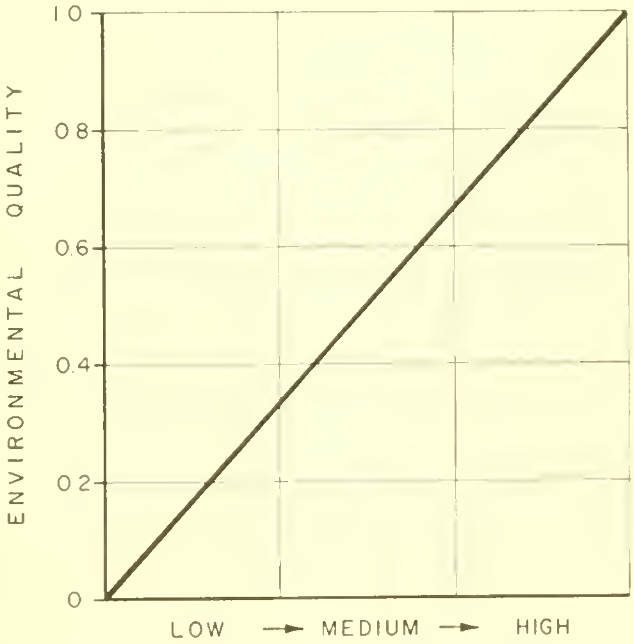


FIGURE 70. MOOD/ATMOSPHERE

In making a "with-without" evaluation of Mood/Atmosphere it would be best if the opinion of more than one person could be used. And it would be best if the evaluations of an area were done by the same people more than one time, with a period of time between each evaluation. The area that is being evaluated should be clearly defined, so that each person is evaluating the same place.

Awe-Inspiration. Awe-Inspiration refers to the feeling toward or respect for nature that is a result of being overwhelmed by the nature of a place. It is the type of feeling that some people get when they see a very high waterfall or when they are in a dense forest of beautiful trees or when they are in the bottom of a deep canyon. An element of peacefulness contributes to this feeling also.

Isolation/Solitude. Isolation/Solitude refers to a state of remoteness, a secluded place, a place where one can go to be alone. People's concepts of what constitutes a place of isolation or solitude will vary considerably depending upon their background and experience. One person, alone in a place twenty miles from the nearest town, may feel very isolated, while another person in the same situation may feel "crowded".

Mystery. Certain places are of interest to people because they provide an element of mystery to be explored — a sense of the unknown. For example, a sense of mystery may result from not knowing what lies ahead beyond the next bend in a river, not knowing what lies ahead in a dense forest, or not being able to understand how such a beautiful place could have come into existence.

"Oneness" with Nature. This concept has to do with a person's feeling of being part of a place and the feeling that the place is an integral part of him. Many people feel that this feeling is necessary before one can "find" himself, or that the feeling is necessary for a renewal of man's spirit.

Life Patterns

The component Life Patterns was added to the EES because it was felt that project impacts directly affecting the everyday lives of human beings' social environment have heretofore not been addressed. The Life Patterns parameters have been designed in such a way that the predominant trend or direction of impacts (beneficial or adverse) can be identified. The parameters are not designed to show intensity of impacts, primarily because the state-of-the-art is such that the relationships between water resource development and its many impacts on society simply are not known at this time. They are designed only to bring attention to the fact that water resource development does affect society, to assist in determining whether the effects are primarily beneficial or adverse, and to cover areas not considered in the economic analysis. The three parameters describing aspects of life activity that may be affected are: Employment Opportunities, Housing, and Social Interactions.

The value function (see Figure 71) for the three Life Patterns parameters (Employment Opportunities, Housing, and Social Interactions) has three major quality-descriptor categories: (1) Existing, (2) Improved, and (3) Disruption to Existing.

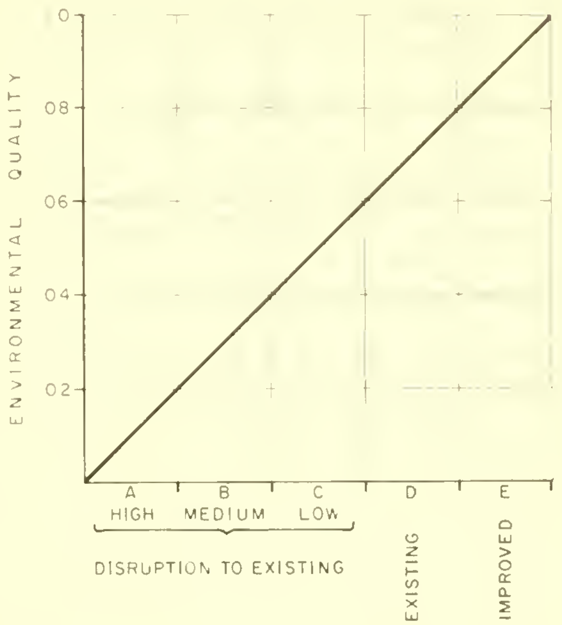


FIGURE 71. LIFE PATTERNS

"Existing" refers to the present level of development in employment opportunities, housing, and social interactions in an area. "Existing" may be assigned a value from .6 to .8, depending upon the level of development in the parameter (low stages of development to highly developed area).

"Improved" refers to any improvement in the situation that may result from a project.

"Disruption to Existing" refers to any disruption occurring to an existing situation. This category is broken down further to indicate the degree of disruption: High disruption (a), Medium disruption (b), and Low disruption (c).

Of major importance in the evaluation procedure for Life Patterns parameters is the identification of sectors of the project area (Downstream, Transfer, Reservoir, and Upstream) which will be affected in any way. Weights (in percentages) indicating importance must be assigned to each sector being evaluated.

Employment Opportunities. Employment Opportunities includes all classifications of employment that may be affected by a proposed project. Bureau of Reclamation projects often result in an increase in available water for industrial use. This may result in an increase in the number of jobs for a particular area. However, a project might also eliminate some jobs in an area, e.g., farming activities, service activities (by elimination of business locations or disruption of access to the population requesting services).

Housing. Housing includes the physical place of residence, yard area, all surrounding property, and any buildings located on that property. These are included in the Environmental Evaluation System because they are often disrupted or affected by water resource development projects. Homes and towns sometimes must be relocated; properties are often lost. The impacts caused by such forced changes and the problems caused to people who must find new homes and properties and the problems involved in relocating must be considered in an impact assessment.

Social Interactions. Social Interactions as a parameter is an attempt to take into consideration the many activities which are a part of people's lives and which cannot be accounted for in the parameters, Employment Opportunities and Housing. Thus, this includes interrelationships created by clubs, schools, churches, and entertainment, recreational, and leisure activities. It also takes into consideration travel patterns and shopping patterns. Bureau of Reclamation projects often disrupt or cut off a number of such interrelationships and patterns. Projects might also enhance some relationships. An example is the creation of more recreational opportunities which would probably result in increased interrelationships. Therefore, all effects resulting in either disruption or improvement of social interactions must be considered, and a judgment must be made as to which effect is most predominant.

QUANTITATIVE ELEMENTS OF THE ENVIRONMENTAL EVALUATION SYSTEM

Environmental impacts from Bureau of Reclamation projects are expressed in Environmental Impact Units (EIU). To express the impacts in these commensurate units, it is necessary to develop for each parameter in the EES a

(1) Value function

(2) Parameter weights in PIU.

The procedures followed to obtain these two elements of the EES are described in this section of the report.

In the development of these two elements, it is important to include individuals that represent a cross section of society. In this way the value functions and weights will not reflect individual bias on the quality of the environment. The value functions and weights published in this report represent the combined judgment of the entire research team which included ecologists, engineers, planners, social scientists and landscape architects.

These value functions and weights represent a suggested starting point for the Bureau and not an inflexible set of judgments. If the Bureau is to use the system effectively, it will be important to modify these elements as more knowledge of public preferences and scientific evidence becomes available. Note, this is the only time that the Bureau should allow any changes in the elements of the EES, and then the "new" value functions and weights should remain in effect until another major revision occurs.

Procedure for Developing Value Functions

Scientific information should form the basis for the development of the value functions. This information would specify the form of the function and the points of inflection or change. In cases where this information is not available, an estimation of the function is necessary. The suggested procedure for this estimation divides the environmental quality range (0-1) into an equal number of intervals. For each of these intervals an estimate of the functional relationship between the environmental quality interval and the parameter value is determined. By connecting these estimates, a representative value function (graph) can be defined.

Value Function Development Steps

In estimating the value function for each parameter, seven steps have to be followed. They are:

STEP 1 Obtain scientific information when available on the relationship between the parameter and the quality of the environment. Also, obtain experts in the field to develop the value functions.

STEP 2 Order the parameter scale so that the lowest value of the parameter is zero and it increases in the positive directions – no negative values.

STEP 3 Divide the quality scale (0-1) into equal intervals and express the relationship between an interval and the parameter. Continue this procedure until a curve exists.

STEP 4 Average the curves over all experts in the experiment to obtain a group curve. (For parameters based solely on judgment, value functions should be determined by a representative population cross section.)

STEP 5 Indicate to the experts doing the value function estimation the group curve and expected results of using the curves in the EES. Decide if a modification is desired; if needed go to Step 3, if not continue.

STEP 6 Do Steps 1-5 until a curve exists for all parameters.

STEP 7 Repeat experiment with the same group or another group of persons to increase the reliability of the functions.

Results of the Value Function Procedure

The value functions developed for each of the 78 parameters are stated in the previous section of this report. Both scientific data and professional judgment were used in the development of these functions.

Procedure for Developing Parameter Weights

The relative importance of the parameters in the EES was expressed in commensurate units (PIU) by quantifying several individuals' subjective value judgments. The weighting technique used by Battelle-Columbus is based on socio-psychological scaling techniques(14-17) and the Delphi Procedure.(18,19) These two methodologies are used to produce a technique that, in general,

- Is systematic in nature
- Minimizes individual bias
- Produces consistent comparisons
- Aids in the convergence of judgment.

Socio-Psychological Scaling Technique

Numerous socio-psychological scaling techniques are available to rank and weight various alternatives or parameters using single or multiple criteria. These techniques are used to insure that the comparison between the elements is consistent and systematic in nature. The technique selected for use in the EES was "ranked pairwise comparisons".

In ranked pairwise comparison, the list of elements to be compared is ranked according to selected criteria and then successive pairwise comparisons are made between contiguous elements to select for each element pair the degree of difference in importance. A weighted list of the elements is the output from this procedure.

Controlled Feedback

Instead of using the initial value resulting from the scaling procedure, an aggregate value based on several iterations of the scaling technique is preferred. After each iteration, the participants are given selected information about the group values. This information can include the group mean and variance, or other pertinent information. In the weighting procedure employed in this research, the participants' mean value was given in the feedback stage. All of the scaling and feedback was performed via formal feedback statements, thereby avoiding undesirable direct interchange of judgments of the individuals in the test.

Relative Parameter Weighting Steps

Parameter Importance Units are assigned to the parameters by first distributing the 1,000 PIU to the 4 categories, then to the 17 quantitative components, and finally to the 78 parameters. That is, the research team specifies, for example, which is more important, esthetics or environmental pollution, and then assigns appropriate weights. The process is continued until all the units are distributed among all parameters.

The parameter weights reflect the relative importance of respective parameter measurements as indicators of the degree to which Bureau of Reclamation projects may disturb or enhance the dynamic stability of man's relationship with the natural and social environment.

In making the estimates of the importance, three criteria are used:

(1) Inclusiveness of parameter

(2) Reliability of parameter measurements

(3) Sensitivity of parameter to changes in the environment.

The Battelle-Columbus technique consists of 10 steps. These steps are briefly outlined below and are followed by a numerical example.

STEP 1 Select a group of individuals for conducting the evaluation and explain to them in detail the weighting concept and the use of their rankings and weightings.

STEP 2 Rank the categories, components, or parameters that are to be evaluated.

STEP 3 Assign a value of 1 to the first category on the list. Then compare the second category with the first to determine how much the second is worth compared to the first. Express this value as a decimal ($0 < x \leq 1$).

STEP 4 Continue with these pairwise comparisons until all in the list have been evaluated. (Compare 3rd with 2nd, 4th with 3rd, etc.)

STEP 5 Multiply out percentages and express over a common denominator, and average over all individuals in the experiment.

STEP 6 In weighting the categories or components, adjust the decimal values from Step 5 if unequal numbers of parameters exist in the parameter groups being evaluated. Adjustment is made by proportioning these decimal values in proportion to the number of parameters included in that grouping.*

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*The hierarchical system shown in Figure 3 has an unequal number of elements in each grouping. To be mathematically correct all levels of the EES hierarchy should have an equal number of elements. However, at the present time, there has not been sufficient knowledge in many of these areas to permit an equal number of elements at the same level of detail. This difference in the number of elements from group to group must be taken into consideration when assigning parameter importance units in the ranking and weighting. Therefore, in the ranking and weighting procedure (Steps 1-5), the researchers were asked to assume an equal number of elements in the groupings being compared. These value judgments were then "adjusted" in proportion to the number of elements in each group. Because the purpose of the weighting procedure was to assign weights to parameters, if an "adjustment" were not made the individual parameters grouped under water pollution would not receive sufficient weight as compared to those under noise because the total number of units available under water pollution would have to be distributed among 17 parameters whereas those for noise would all be assigned to the single noise parameter. For this reason, comparisons between components and categories should be based on average values of the PIU for the grouping not the sum of the values.

STEP 7 Multiply these averages by the number of environmental units to be distributed to the respective grouping.

STEP 8 Do Steps 2-7 for all categories, components, and parameters in the EES.

STEP 9 Indicate to the individuals by controlled feedback the group results of the weighting procedure.

STEP 10 Repeat the experiment with the same group of individuals or another group to increase the reliability of the results.

For a numerical example consider three components (A, B, C) that have been selected in Steps 1 and 2. These components consist of 8 parameters, 4 in A, 2 in B, and 2 in C.

STEP 2 Ranking of component – B, C, A

STEPS 3, 4 Assign weights

B = 1
C = 1/2 the importance of B
A = 1/2 the importance of C

STEP 5 Multiply out percentages and express over common denominator. Assume the average values of all individuals are given below.

B = 1
C = .5
A = .25
———
1.75

B = 1/1.75 = .57
C = .5/1.75 = .29
A = .25/1.75 = .14
———
1.00

STEP 6 Adjust for unequal number of parameters in each component.

B = .57 x 1/4 = .14
C = .29 x 1/4 = .07
A = .14 x 1/2 = .07
———
.28

Using the new total, the components values are

B = .14/.28 = .50
C = .07/.28 = .25
A = .07/.28 = .25
———
1.00

and the average values are

B = .50/2 = .25

C = .25/2 = .135

A = .25/4 = .0625

STEP 7 Multiply these adjusted values by appropriate PIU, which in this case is 20.

20 x .5 = 10

20 x .25 = 5

20 x .25 = 5

STEP 8 Continue until reliable estimates are obtained.

Results of the Weighting Procedure

The procedure outlined above was followed by the research team. The PIU that resulted are listed in Figure 3, a foldout in the front of the report.

The importance of categories and components is based on average Parameter Importance Units because of the unequal number of parameters in each grouping. The ranking of these categories and components is given in Table 3 and the parameters in Figure 72.

TABLE 3. RELATIVE IMPORTANCE OF CATEGORIES AND COMPONENTS

SECTION I

Category	Average Value of Parameters in PIU*
Environmental Pollution	17
Ecology	13
Human Interest	11
Esthetics	9

SECTION II

Component	Average Value in PIU*
Water Pollution	23
Composition	15
Species and Populations	14
Land Pollution	14
Habitats and Communities	13
Life Patterns	12
Educational/Scientific Packages	12
Historical Packages	11
Land	11
Man-made Objects	10
Water	10
Cultures	9
Mood/Atmosphere	9
Air Pollution	7
Biota	6
Noise Pollution	4
Air	3

* Averages are rounded to integer values.

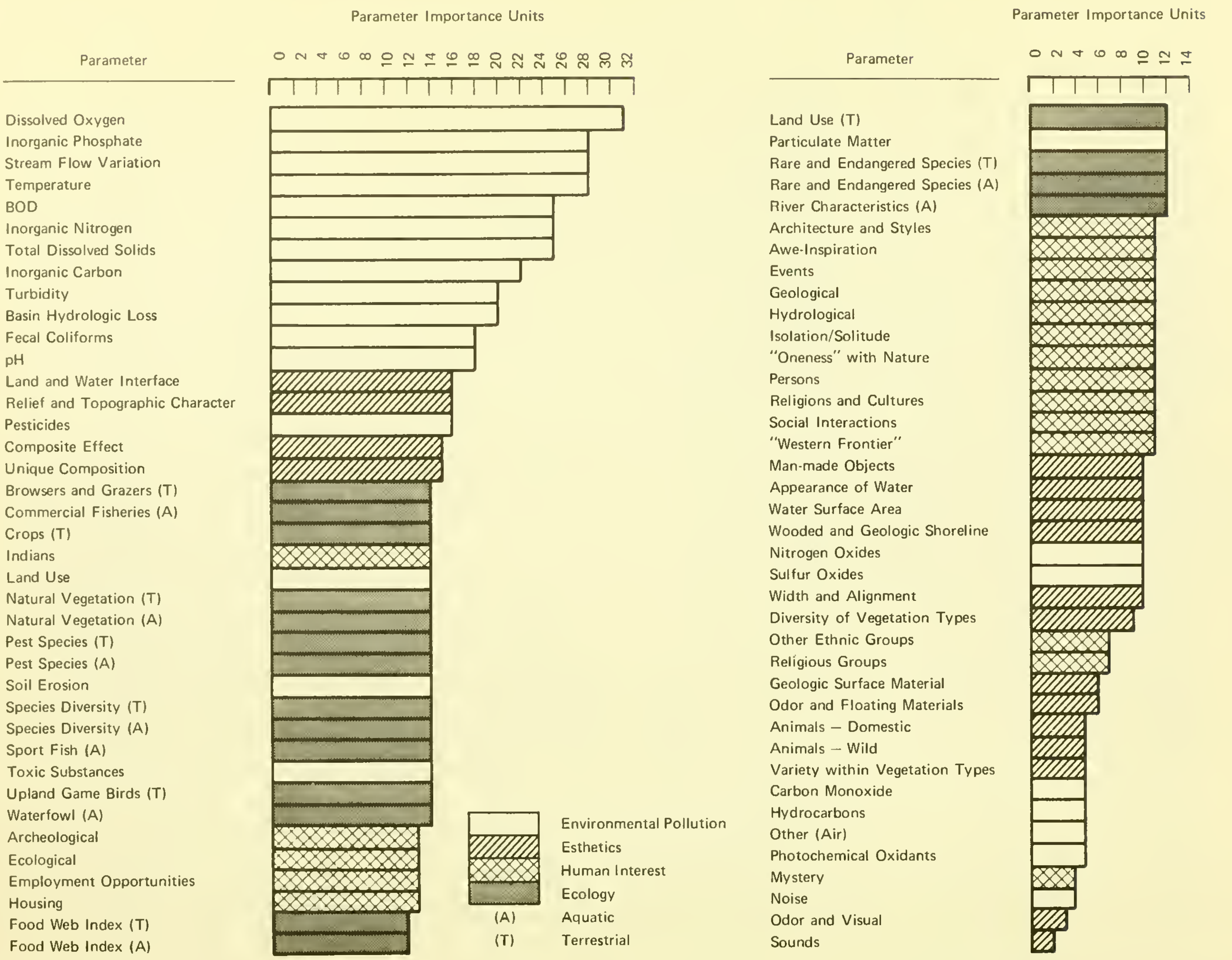

FIGURE 72. RELATIVE IMPORTANCE OF THE EES PARAMETERS

PROCEDURE FOR USING ENVIRONMENTAL EVALUATION SYSTEM

The EES can be applied both in the evaluation of project impacts to select specific alternatives, and in the planning process to minimize potential adverse impacts in future projects. There is no difference, however, in the way the EES is used, only in how the results are applied. These two applications are related to the overall water resource development process as shown in Figure 73.

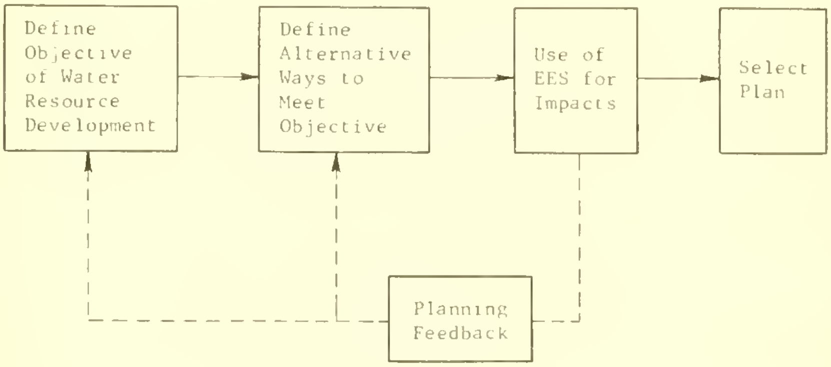
Define Objective of Water Resource Development
Define Alternative Ways to Meet Objective
Use of EES for Impacts
Select Plan
Planning Feedback

FIGURE 73. ENVIRONMENTAL ASPECTS OF WATER RESOURCE DEVELOPMENT PROCESS

When the EES is applied only to screen alternatives, the information obtained is normally not used to modify the project alternatives. However, when the EES is applied in the planning process, the feedback loop and the EES output are continually used to modify the proposed project in ways that will reduce the number of "red flags" and raise the total "with" score (EIU). Projects developed by this process would be expected not only to avoid or minimize adverse environmental impacts, but also to improve selected portions of the environment.

In using the EES it is important that an interdisciplinary team be involved in the analysis. This may be a problem because of the limited number of ecologists, social scientists, and landscape architects in the Bureau of Reclamation. Much of the data needed for the EES can be obtained from other Federal agencies which employ individuals trained in these areas. By developing a working relationship between these agencies an "interdisciplinary team" can be formed. It is important, however, that an individual with broad understanding of most of these areas supervise the use of the EES and interpretation of the results.

The suggested procedure for use of the EES consists of five steps to conduct the "with" and "without" evaluations:

(1) Define boundaries for study

(2) Obtain parameter measurement data

(3) Determine EIU

(4) Determine "red flags"

(5) Report information in EES summary.

Step 1. Define Boundaries for Study

Boundaries are used in a broad context to denote

(1) Bureau responsibility

(2) Spatial and temporal considerations

(3) Ecosystems affected.

Bureau Responsibility

Activities of the Bureau are designed to bring about physical changes in certain areas of the West, and consequently can cause significant environmental impacts. Some of these impacts are directly attributable to a specific project. Others reflect environmental changes brought about only partially by Bureau activities.

Two kinds of impacts from Bureau projects can be defined:

- Construction Impacts – resulting from physical changes made in the environment by the Bureau in building a project
- Use Impacts – resulting from using Bureau project sites, or from using water or power.

Both construction impacts and use impacts may be directly or indirectly attributable to Bureau projects. Direct-construction impacts, indirect-construction impacts, and direct-use impacts are all the responsibility of the Bureau, whereas indirect-use impacts are not.

Nature of Impact	Direct	Indirect
Construction	*	*
Use	*	

* Impacts for which Bureau should use EES.

Construction Impacts. When the Bureau constructs a project, it purposely brings about physical changes such as moving earth, clearing trees, storing water, dredging rivers, lining channels, erecting structures, etc. Any environmental impact resulting from such physical changes is defined as a direct-construction impact which should be reflected by an EES evaluation.

When the Bureau constructs a project, certain physical changes occur in the environment, either predictably or unpredictably, that are incidental to the purposes of the project. Such changes include increased evaporation, change in river temperature, reduced stream flow, change in flyway patterns of migratory birds, decrease in number of aquatic species, etc. Any environmental impact resulting from such physical changes is defined as an indirect-construction impact and should also be reflected in evaluations conducted with the EES.

Use Impacts. Specific users or beneficiaries of Bureau project development may be users of Bureau water, power, or other aspects of Bureau projects. Often, Bureau power or other project resources are used in ways that result in environmental impacts. Among these impacts are effects on recreational use of Bureau impoundments, effects caused by users of agricultural waters – such as high salinity return flows, and the effects of predictable development around reservoir perimeters – such as recreation areas, vacation home developments, motels, etc. If Bureau water or power is specifically designated for the development of a new industrial plant, power plant, or other potential pollutor, then the impacts from these developments would also fall in this category. Thus, where the use of Bureau projects leads directly to environmental effects, these may be considered to be direct-use impacts which should also be reflected in EES evaluation.

Direct-use impacts are often avoidable if enough money is devoted to environmental protection measures in the development of such uses. For instance, if tourist and recreation camps are constructed with adequate waste treatment facilities, there may not be any pollution impact, but if such facilities are not provided, there most certainly will be. Where use impacts are avoidable – at a cost – it is recommended that in applying the EES, it be assumed that such impacts will be avoided. However, in performing the project economic evaluation, the cost of avoiding environmental impacts must also be included in any calculations of benefits and costs. In addition, the overall environmental evaluation should be accompanied by a description of any major economic investment upon which the EES analysis is predicated.

Where a Bureau project benefits users in a general, nonspecific manner, indirect-use impacts may result. For instance, Bureau water and power may contribute to the growth of a city of 50,000 people to a size of, say, 60,000. Accompanying this growth will be environmental problems: water polution due to inadequate sewage treatment plants, air pollution due to increasing numbers of automobiles, wildlife losses due to urban sprawl, etc. The impacts of these kinds of uses of Bureau project water and power are not directly attributable to the Bureau project – but are a function of conditions already existing in the city at the time the Bureau project was built. It is felt that indirect impacts of this nature are beyond the bounds of Bureau responsibility, and the Bureau should not be held accountable for them. On the other hand, as a public agency, the Bureau has an obligation not to encourage developments and uses of its projects that will, in its judgment, lead to an unjustified degradation of the environment, whatever the cause.

Spatial and Temporal Considerations

Construction and use impacts may occur at various locations in the project area and during different time horizons. To avoid omitting any impacts, it is important to include systematically both spatial and temporal considerations in the EES.

Spatial areas that must be considered are conveniently divided into four sectors:

(1) Upstream from the proposed development

(2) At the site of the proposed development

(3) Along routes of transfer from one sector in the development to another

(4) Downstream from the proposed development.

Selection of the extent of the area to be included in each of these sectors is determined by the team doing the impact analysis. These sectors are meant to be only a framework for including the spatial considerations in the EES.

In the evaluation of "with" the project, it is important to recognize the different impacts on the environment during each of these time periods, some short-term, others long-term. Battelle-Columbus recommends the use of two time frames in the use of the EES to evaluate the "with" project conditions:

- Construction (short-term)
- Operation (long-term).

Ecosystems

As was stated earlier in the report, ecosystems will not be directly included in the EIU evaluation. For the present time, this category will be used as a macro-level descriptor of the area. To insure that the description of ecosystems is an important part of the EES, Battelle-Columbus recommends that such descriptions take place "with" and "without" the project. Any change in the ecosystems in the project area could be noted in a narrative section of the EES summary and appear as a "red flag" if there is significant adverse change.

Work Sheet

To integrate considerations relating to Bureau responsibility, spatial and temporal factors, and ecosystems during the use of the EES, a work sheet is recommended. The Battelle-Columbus research team used such work sheets in documenting parameter measurements (fourth hierarchical level of information; see Figure 1). Work sheets provided a convenient way of using the EES and referring to the measurements later. A suggested work sheet is given in Figure 74.

Measurements for Parameter: ____________________

Date of Measurement: ____________________

Spatial Time	Upstream	Site	Transfer	Downstream
Without Project				
Construction (With Project)				
Use (With Project)				

FIGURE 74. WORK SHEET

In each cell of the worksheet, measurement data for a specific parameter can be recorded. This work sheet can also be used in the description of the ecosystems of the project area.

Step 2. Obtain Measurement Data

Parameter estimates are used in conjunction with the value functions to determine environmental quality (EQ) scores. Parameter estimates must be developed from all of the information defined in the previous work sheet considering Bureau responsibility, and spatial and temporal considerations.

Sources of parameter measurement data include

- Federal, state, and local agencies
- Universities
- Private citizens, civic groups, special interest groups
- Environmental special interest groups
- The Bureau of Reclamation, through data-gathering programs
- Published reports and journals.

Battelle-Columbus found that during the Bear River Study these sources can provide most of the information needed to use the EES.

Step 3. Determine EIU

At this point in the use of the EES, a work sheet has been filled out with measurement data for each of the 78 parameters. Each of these work sheets must now be transformed into an environmental quality value for each parameter for the "with" and "without" project conditions. This is achieved by (1) assigning a relative importance, based on professional judgment, to the respective elements of the evaluation – upstream, site, construction, etc., (2) multiplying this importance factor by the representative parameter measurement for each element, and (3) summing the relevant cells for the "with" and "without" values.

$$\text{Parameter value ("with" or "without")} = \sum_{i}^{n} \sum_{j}^{m} C_{ij} X_{ij} \quad , \qquad (23)$$

where

i = Spatial index

j = Temporal index

C_{ij} = Importance of cell ij

X_{ij} = Measurement in cell ij

n = Number of spatial areas considered

m = Number of time factors considered.

An example of using the work sheet is shown below using the data measurements in the work sheet given in Figure 75. Calculations for the representative parameter values for dissolved oxygen are:

$$
\begin{aligned}
\text{"without"} &= .25(8) + .50(10) + .25(8) \\
&= 2 + 5 + 2 \\
&= 9 \text{ mg/l} \\
\text{"with" (construction)} &= .25[.25(4) + .50(2) + .1(5) + .15(4)] \\
&= .25(1 + 1 + 0.5 + 0.6) \\
&= .77 \text{ mg/l} \\
\text{"with" (use)} &= .75[.25(4) + .5(4) + .1(4) + .15(4)] \\
&= .75(1 + 2 + 0.4 + 0.6) \\
&= 3 \\
\text{Total "with"} &= 3.77 \text{ mg/l}
\end{aligned}
$$

Once a parameter estimate for a "with" or "without" condition has been determined, it is used to enter the value function. The output of the value function is an indicator of environmental quality between 0 and 1. It is important to estimate this environmental quality to two decimal places to maintain the desired accuracy in the total EIU.

For this example the environmental quality as measured in Figure 24 would be:

$$
\begin{aligned}
\text{"without"} &= 9 \text{ mg/l} &&= 1.0 \\
\text{"with"} &= 3.77 \text{ mg/l} &&= .3
\end{aligned}
$$

To obtain either the "with" or "without" evaluation in EIU, it is necessary to determine the EIU for each specific parameter and then sum over all 78 parameters. An impact evaluation is determined by using the following equation:

Environmental Impact in EIU = Evaluation "with" Project − Evaluation "without" Project

$$EI = \sum_{i=1}^{78} w_i EQ_{i(\text{with})} - \sum_{i=1}^{78} w_i EQ_{i(\text{without})} , \qquad (24)$$

where

i = parameter index

w_i = relative importance of parameter i in PIU

EQ_i = environmental quality coefficient from value functions.

In the formulation used, a negative (-) change indicates an adverse environmental impact and a positive (+) change indicates a beneficial impact.

Measurements for Parameter: Dissolved Oxygen

Date of Measurement: Average Data 1950 to 1971

Spatial / Time	Upstream	Site	Transfer	Downstream
	Relative Importance = 0.25	RI = 0.50	RI = 0 (without) RI = 0.10 (with)	RI = 0.25 (without) RI = 0.15 (with)
Without Project Relative Importance = 1.0	Modified Current $\frac{8+6+10+8}{4} = 8 mg/l$	Modified Current $\frac{8+12}{2} = 10 mg/l$	———	Modified Current $\frac{6+6+10+10}{4} = 8 mg/l$
Construction (With Project) RI = 0.25	Predicted $\frac{4+2+6+4}{4} = 4 mg/l$	Predicted $\frac{1+3}{2} = 2 mg/l$	Predicted $\frac{4+6+5}{3} = 5 mg/l$	Predicted $\frac{2+2+6+6}{4} = 4 mg/l$
Use (With Project) RI = 0.75	Predicted $\frac{4+2+6+4}{4} = 4 mg/l$	Predicted $\frac{4+4}{2} = 4 mg/l$	Predicted $\frac{4+4+4}{3} = 4 mg/l$	Predicted $\frac{3+3+5+5}{4} = 4 mg/l$

FIGURE 75. WORK SHEET EXAMPLE

For this example:

$$EI = 31(PIU) \times (.3) - 31(PIU) \times (1.0)$$
$$= 9.3(EIU) - 31(EIU)$$
$$= -21.7\ EIU$$

Step 4. Determine Red Flags

Problem areas and data gaps in any proposed project are keyed in the EES by the use of "red flags". Elements of the environment that may be significantly changed in an adverse direction are represented as either a minor or major "red flag". These "red flags" indicate where a detailed investigation is necessary. In areas where there are either no data or only qualitative data "red flags " are used to indicate data needs.

Four rules are used to determine if a negative change in a parameter constitutes a "red flag" and the type of flag that should be used. Each of these rules is based on a change in the parameter's environmental quality as measured by the extent of difference between the "with" and "without" evaluations. Recall that the environmental quality of a parameter is determined from the value function.

For Ecology parameters:

RULE 1 Minor Flag: The negative change in percent between the "with" and "without" environmental quality is between 5 and 10 percent*.

RULE 2 Major Flag: The negative change in percent between the "with" and "without" environmental quality is greater than 10 percent.

For all other Parameters:

RULE 3 Minor Flag: The negative change between the "with" and "without" environmental quality is greater or equal to 0.1 in absolute value. This change in percent is less than 30.

RULE 4 Major Flag: The negative change between the "with" and "without" environmental quality is greater or equal to 0.1 in absolute value. This change in percent is greater or equal to 30.

These rules were determined by an analysis of the various parameter sensitivities to change and the significance of change as determined from the field test described in the next section of this report. Because these rules are based on a small sample, further tests are necessary to substantiate them. The macro nature of the ecology category is the primary reason for the differentiation in the "red flag" rules. Field

---

$$* \text{ Percent} = \frac{\text{"with" EQ} - \text{"without" EQ}}{\text{"without" EQ}} .$$

tests indicated that a small change in the ecology parameters was comparable in impact to larger changes in all other parameters which are less macro in nature.

For the example discussed in Step 3, the test for a "red flag" is made by using Rules 3 and 4. The absolute value of the environmental change is .7, which is a 70 percent change in the parameter. Therefore, the dissolved oxygen parameter is defined as a major "red flag".

Step 5. Report Information in the EES Summary

It is desirable to include all the important results of an environmental impact analysis in a summary table. This summary table would enable decision makers to obtain an overview of the environmental impacts from the project by reviewing a single table. If more detail is desirable, however, it can be obtained from the supporting data.

The summary table used in the EES included three important results from the environmental impact analysis:

(1) Net environmental impact measured in EIU

(2) Minor and major "red flags"

(3) Data needs.

In using the EES to obtain a net environmental impact in EIU, it is possible that quantitative data on all parameters would not be available. However, some qualitative data, information gathered in field studies that cannot be substantiated by a reliable documented record or reduced to quantifiable form, may be available. Because this information is useful in the determination of environmental impacts, it is included in the EES.

Qualitative data are included in the EES in a special way. Because there is no reliable data to determine a "with" or "without" evaluation, it is only possible to estimate a percent change in a parameter. This estimated change is then multiplied by the parameter's weight to give an estimated change in EIU which can be included in the EES.

RESEARCH NEEDS

The EES provides a tool that can be used now by the Bureau of Reclamation, and one that draws upon the best information available. It is recommended that during the course of the application of the EES by the Bureau, attention be given to those areas where research could provide better information and data for performing environmental impact analyses. In addition, the Bureau can anticipate having to increase its staff in the environmental disciplines and to expand its efforts during the planning stage of each project to collect the data and perform the analyses associated with each project plan.

Continued Development of the Environmental Evaluation System

Continued development of the EES by the Bureau of Reclamation is desirable in three research areas:

(1) Improvement of the parameters in the EES
(2) Increasing the data availability for parameters in the EES
(3) Refinement of the weights and the value functions.

Improvement of the Parameters in the EES

The present EES consists of 4 categories, 18 components, and 78 parameters. Battelle-Columbus feels that at the present time this is the best comprehensive list possible. However, as the system is used and research increases in this area, it is expected that the EES will be refined. Refinement will include the addition of parameters in areas where current measurement and evaluation are not possible, and the replacement of existing parameters with ones more inclusive.

Ecology. Because the science of ecology has not, until recently, focused on the kinds of applications that environmental impact evaluations require, there has been insufficient progress made in the development of suitable ecological parameters. In the past, most ecologists devoted their efforts to the study of single species, organisms, or to specifics rather than to the complex interactions that determine the kinds of changes that will occur within a river basin system or other natural systems as a result of changes caused by water resource projects.

Parameters are included in the EES to measure the appropriate changes in the ecological processes. As better measurements and interpretations of these ecological processes occur they should be incorporated into the EES. Ecosystems is an area of major concern which is included in the EES as a descriptor and modifier. It is desirable to include this area in the quantitative framework as soon as possible.

Environmental Polution. Parameters that are used in the EES and in other systems are specific in nature. That is, they fail to reflect the interactions that occur between two separate effects. For example, toxic substances have a profound impact on aquatic life, as does temperature. However, the use of these two significant parameters in no way expresses the combined effects of temperature and toxicity on aquatic organisms. It is probably too difficult to develop parameters that express these kinds of interactions throughout the system to assure that they are given proper attention during the evaluation.

In addition to including in the EES parameters that measure interactions, improvements in some existing parameters are necessary. Stream flow variation is an original attempt to relate several important factors to environmental quality. It needs to be field tested on a variety of situations, and suitably modified before it can attain the operation reliability inherent in most other water quality value functions.

Land use is a complex factor that must be considered in water resource development. In the EES it is reduced to two measurements – density of development and percent of land developed. It also needs to be field tested and refined to attain additional operational reliability.

Esthetics. Esthetics, being a function of a person's subjective response to his environment, requires a completely different kind of analysis and research than does ecology and environmental pollution. Research needs in esthetics relate to determining with greater confidence the esthetic impact of water resource development on people.

Esthetic "values" used in the development of the esthetic parameters and value functions are a function of the experiences and "values" of the research team. These values should be tested to determine if they adequately represent the esthetic values of society. The testing should be carried out at different locations in the West so that the visual perception of plains, mountains, deserts, forests, reservoirs, etc., are all considered.

The esthetic category was divided into components and parameters that describe the important elements of a "scene". This concept of breaking a subjective judgment into discrete elements must also be tested in a number of situations to determine its reliability.

Human Interest. Considerations of human interest have always been made in the planning of Bureau of Reclamation projects, but rarely have been included as a formal element in project analysis. Because these factors represent a considerable portion of the total environmental impact of projects, better and more systematic information is needed in this general area of evaluation.

A better understanding of the relationship between water resource development and social aspects of communities needs to be determined. The research effort needs to be directed at identifying and analyzing (a) the structure of a community, (b) the elements that contribute to the strengths or weaknesses of that structure, and (c) the sensitive elements of that structure. Once this information is known, additional parameters can be included in the EES that are quantitative in nature, and more relevant to the component of Life Patterns.

An inventory should be made throughout the Bureau of Reclamation territory of sites of human interest value in the education/scientific, historical, and cultural categories, to be further classified according to specific types. Such an inventory should be made with leading experts in the relevant fields, such as historians, geologists, archeologists, etc. Naturally, once such an inventory is made, it should be updated as new archeological finds are made, and as more is learned about nature and the significance of natural areas.

Data Availability

Field testing of the EES indicated that there are some areas in which data are currently not being gathered by any agency. In other areas, however, data were readily available in the desired format or could easily be manipulated to the desired format. Where data gaps exist, the Bureau will have to gather this information themselves, or make arrangements with another agency to obtain the data. Specific parameters which are expected to be data problems in using the EES are discussed below.

Ecology. In the ecology category some of the data is not published and therefore is not readily available to be used in the EES. Parameters, for which information can for the most part be obtained from existing files but appear as gaps, are

- Upland Game Birds
- Aquatic and Terrestrial Pest Species
- River Characteristics.

In other cases the data must be obtained from field surveys and existing file information. These are

- Aquatic and Terrestrial Species Diversity
- Aquatic and Terrestrial Food Web Index.

Environmental Pollution. Many of the water pollution parameters included in the Environmental Pollution category are presently being measured by the USGS, EPA, and various agencies. However, the pesticide levels in many of the rivers and streams of the West are not currently being measured because the analyses are extremely costly to conduct and because cognizant agencies do not "expect" them to be a problem. Pesticide measurements are becoming more important as individuals recognize that pesticides are one of the major factors influencing the health and well-being of aquatic ecosystems.

Air quality is not measured in all areas of the western states. First priority is given to areas where known problems exist, namely cities. In many of the nonurban areas definite air pollution problems do exist but are very local, being confined to the immediate area downwind of specific industrial sources. Technology does exist for conducting area-wide surveillance for the air quality parameters in the EES. A rather comprehensive and costly grid is required, however, to obtain meaningful data. This is in contrast to the situation in water quality where surveillance can be limited to the water course in question.

Noise pollution is not now and will not likely become a sufficiently severe problem in those areas of the West in which Bureau projects are likely to be built, to warrant routine collection of noise data. Thus, data will have to be collected on a case-by-case basis. This is not a major problem, however, since equipment is available (cost \$200-\$300) for making db(A) measurements.

Esthetics. The data used in the esthetic category of the EES is gathered by the evaluation team during the planning or impact analysis of each specific project. Therefore, there are no data gaps in esthetics. However, if the Bureau could develop a "data bank" on the esthetic value of different Bureau regions and subregions, it would be helpful not only in the use of the EES but also in the selection of potential project development areas.

Human Interest. The need for improved data is evident for two of the educational/scientific parameters: archeological and geological. For both parameters some data is available in the western states depending upon the geographical area. But in most areas, especially relatively unknown or unsettled areas, little data on archeological and geological significance is known.

Data is also needed in the component called Life Patterns. Information on the social structure of towns, villages, and cities, and how these structures are affected by water resource projects is not available at the present time. As in the esthetic category, the data for Mood/Atmosphere is gathered separately by the evaluation team for each specific project.

Refinement of Weights and Value Functions

The weights and value functions given in this report were developed by an interdisciplinary research team at Battelle-Columbus. Therefore, the weights and value functions reflect the combined judgment and personal opinions of the research team. In the long run, the weights should be refined to better reflect the views of society.

Value functions represent in some cases a good correlation between parameter measurements and environmental quality. However, in others it is only a judgment of the researchers involved in the development of the EES. These value functions should be inspected by experts in the appropriate fields to aid in their refinement.

Personnel Needs

Training of Existing Personnel

Individuals employed by the Bureau of Reclamation who have training in engineering, economics, and related areas must become involved with the EES to make it work. Their involvement varies, however, depending on their role in the existing structure and in any new structure involving use of the EES. Each of the individuals must understand what the EES is and why it is important.

Once this information is communicated to them, their role in the use of the EES will be facilitated. Existing personnel can then be used in data gathering, some analysis, interaction with other agencies, and performing environmental impact analyses.

Hiring of New Personnel

The use of the EES in the planning and evaluation of Bureau projects will require the hiring of additional personnel. These individuals should be trained in disciplines such as environmental planning, sociology, ecology, and landscape architecture.

Suggested Research Program

The EES described in this report must be improved on a continual basis if it is to be an important part of the Bureau's planning process. To be meaningful to the Bureau, the suggested improvements in the EES discussed in the previous section should be developed in a systematic program. Such a program would guide the Bureau in determining what should be done now that the EES has been developed. Because any research program requires trained personnel to perform the research, the personnel needs of the Bureau are included as part of the program.

The proposed research program consists of 6 parts which are listed in a suggested order of implementation.

(1) Test the EES Using Bureau of Reclamation Personnel

The EES has been developed and field tested by Battelle-Columbus. It is now necessary for Bureau personnel to use the EES on a proposed project or in a project workshop setting. Use of the EES by the Bureau will enable them to evaluate the advantages and limitations of the EES. It will also help the Bureau to select personnel to be used in environmental evaluations.

(2) Develop a Field Manual

After the EES has been used by Bureau personnel it will be necessary to write a field manual describing the detailed steps that must be followed by other Bureau personnel in conducting environmental evaluations with the EES. This field manual should be written by Bureau personnel who understand the EES, Bureau operations, and Bureau requirements for manual format.

(3) Initiate Research Programs in Ecology and Human Interest

Research programs are needed in ecology to understand, interpret, and measure ecosystems. A detailed ecological analysis of a river basin would provide an excellent opportunity for this research. In the Human Interest category, research is needed to improve understanding of the relationships between water resource development and the social environment of a community. By studying a specific community prior, during, and after it is influenced by a water resource development project, valuable information on these social relationships can be obtained and used in the Life Patterns category of the EES.

(4) Refine Value Functions

The Value Functions included in the EES have not been tested on a wide spectrum of water resource projects. Experiments should be conducted by Bureau personnel to test these functions and to refine the curves.

(5) Improve Other Parameters in the EES

The data available for all other parameters in the EES should be increased through specific research programs. A major effort should be directed in the Esthetics and Human Interest categories. In addition to increasing available data, research programs should be directed at testing and improving the parameters used in the EES. Emphasis should be placed in the Esthetics category.

(6) Refine the Weights

The weights given in the EES are a function of the Battelle-Columbus research team. Effort should be made to include a more representative number of individuals in a refinement of the weights.

FIELD TESTING OF THE ENVIRONMENTAL EVALUATION SYSTEM

BACKGROUND INFORMATION FOR FIELD TESTING

The second phase in the development of the EES was to field test and refine the system. The area selected by the Bureau for the field test was the Bear River Project in Utah, Idaho, and Wyoming (Figure 76).

Description of the Bear River System

The Bear River is the largest river in America that has no outlet to the ocean. Its headwaters are in Utah, high in the Uinta Mountains, and it flows northward crossing the state lines of Wyoming and Idaho until it reaches Soda Springs, Idaho. It then reverses its northern course and flows southward ending in the Great Salt Lake (see Figure 77). Although the river is 500 miles long, the distance between its headwaters and its terminus in the Great Salt Lake is only about 90 air miles.

Bear River water is presently used for irrigation, hydroelectric power, municipal and industrial water supply, and maintenance of the Bear River Migratory Bird Refuge. These water needs are supplied by reservoirs throughout the system. The average annual flow in the headwaters is about 130,000 acre-feet and the flow at Corinne, Utah, near the Great Salt Lake, is about 1,000,000 acre-feet.

At the present time no comprehensive basin-wide plan has been developed to meet water needs in the Bear River Basin as projected by the Bureau of Reclamation. However, several alternative segments have been selected that could be woven into a basin-wide plan. Each of these segments was designed to satisfy part of the basin's water need for additional irrigation, municipal and industrial water supply, and fish and wildlife. The proposed segments are listed below and given in Figure 77.

(1) Oneida Narrows[*] (I, M&I, F&W)[**]
(2) Caribou (I, M&I)
(3) Bennington (I, F&W, FC)
(4) Thomas Fork - Smiths Fork (I, F&W, FC)

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[*] In this report, Large Oneida Narrows will be referred to as Oneida Narrows.

[**] I = irrigation, M&I = municipal and industrial water supply, F&W = fish wildlife, FC = flood control.

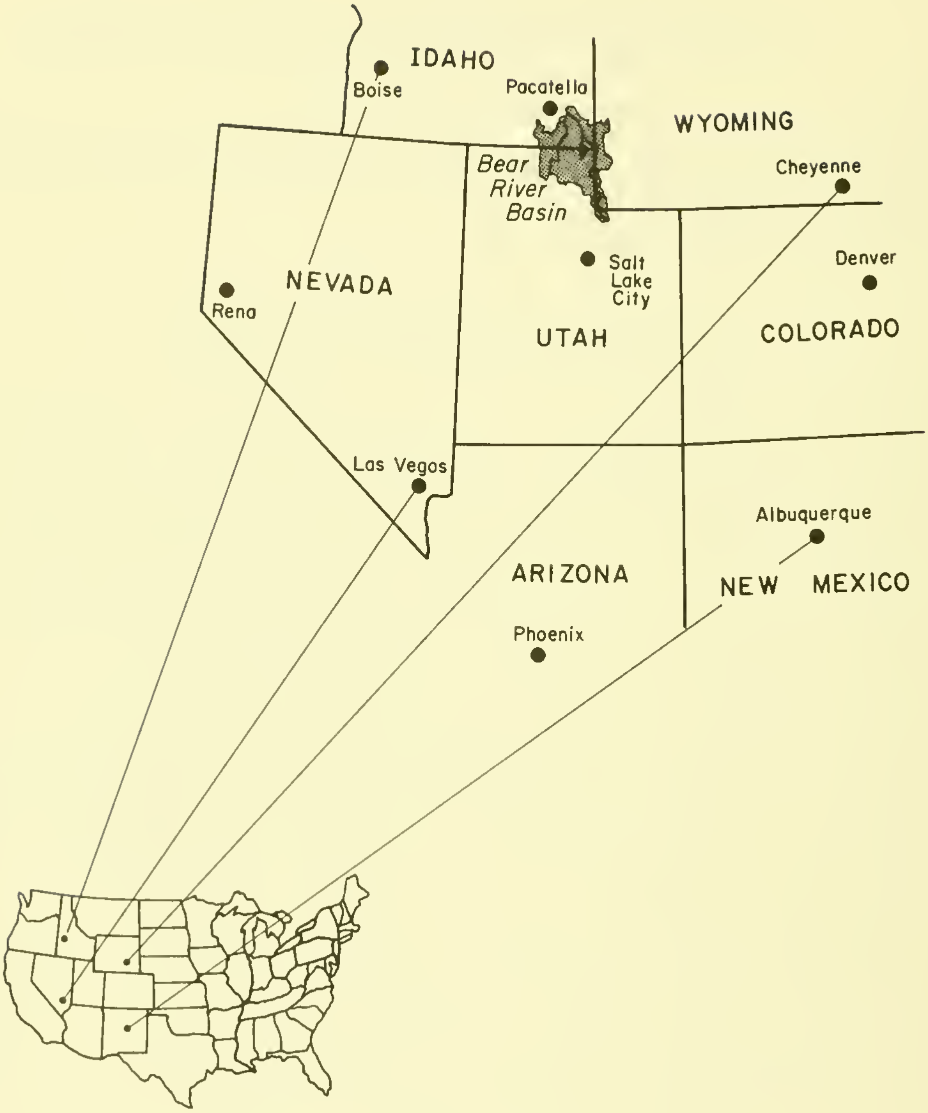

FIGURE 76. LOCATION OF BEAR RIVER BASIN

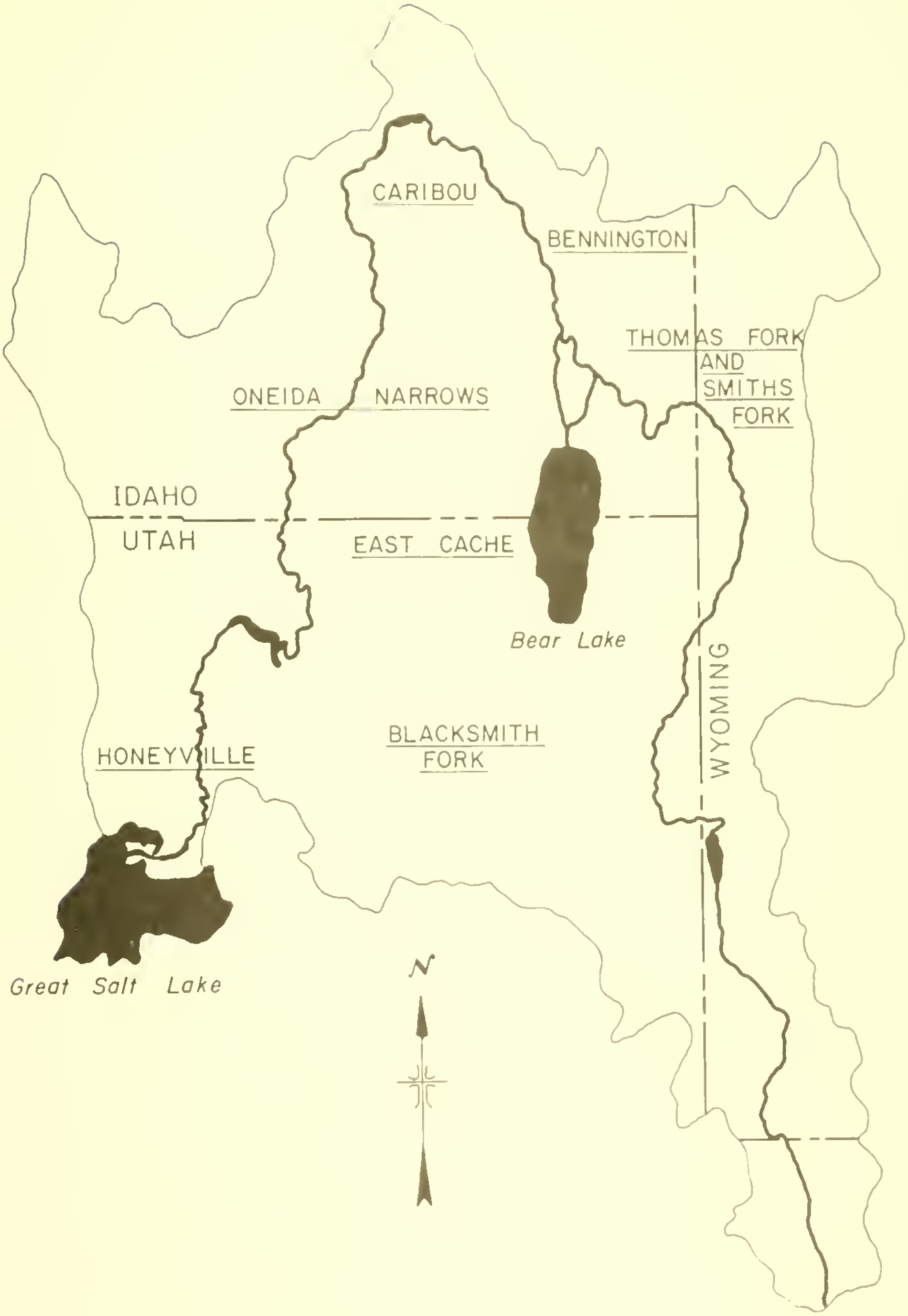

FIGURE 77. BEAR RIVER BASIN

(5) East Cache (I, M&I, F&W, FC)
(6) Blacksmith Fork (I, M&I, F&W, FC)
(7) Honeyville (M&I, F&W, FC).

For more detail on these segments see "Bear River Investigations, Idaho, Utah, Wyoming", Status Report, June 1970, by the Bureau of Reclamation(20).

Ecosystems in Bear River Basin

The Bear River drainage basin includes a variety of terrestrial and aquatic ecosystems. It is located at the eastern edge of the Great Basin and Range Geologic Province demarcated by the Wasatch Range. Approximately one-half of the drainage basin is actually east of this Province, but this area is very similar to that portion of the basin within the Province. The Province is characterized by basins or valleys interrupted by small north-south oriented mountain ranges of moderate to high elevations. This area is semi-arid with only the higher elevations receiving more than 20 inches of precipitation annually. This low precipitation is a result of the rain shadow caused by the Sierra Nevada Mountains at the western limit of the Province and the numerous smaller ranges between the Bear River Basin, the western boundary of the Province.

The Bear River has its headwaters in the north slopes of the western end of the Uinta Mountains. The altitude may exceed 12,000 feet, so much of the water comes from melting snow. The gradient from the headwaters to Evanston, Wyoming (elevation 7000 feet) is steep. The terrestrial ecosystems here are typical mountain types. The alpine meadows occur at the highest altitude (12,000 feet) where some soil has accumulated. Sedges (Carex) and grasses (Festuca, Poa, and others) are the dominant plants. Resident animals include the marmot, Uinta ground squirrel, and northern pocket gophers plus spiders, orthoptera, leafhoppers, and other insects. In rugged rocky areas only lichens and some species of Salix are found. Here the pika is common and the golden mantled ground squirrel is found.(21) Several species of birds (rock wren, Wilson's warbler, white-crowned sparrow) nest in this area. At somewhat lower elevations, at about timber line, the wind timber belt begins. Large mammals such as elk and sheep may use this area. Here the climax species include spruce fir, Engelmann spruce, and subalpine fir.(21) Because of the severe temperature, high winds, and heavy snowfall, these trees are stunted. Animals of the alpine meadows may seek shelter here. Most of the mammals found here are also found in either the alpine meadows or montane forest. Breeding birds include the pine grosbeak, brown creeper, and golden-crowned kinglet. The wind timber forest forms a belt of varying width around the mountains. Below that belt is the montane forest. This forest is subdivided into two regions - the upper and the lower - according to altitude. The upper montane forest ranges from 8,000 to 12,000 feet depending on the specific conditions at each locale. Dominant trees are the Engelmann spruce, subalpine fir, lodgepole pine, and others.(21) Aspen and lodgepole pine are common in areas which have been disturbed. A distinct shrub layer occupied by Vaccinium, Lonicera, Salix, and Ribes is also present beneath the dominants. The forest thins as the altitude increases. Larger mammals do not frequent the denser portions of the forest. Deer, bighorn sheep, elk, and some other species will use the less dense areas. Small mammals include yellow-haired porcupine, snowshoe hare, striped skunk, long-tailed weasel, Uinta ground squirrel, red squirrel, pocket gopher, several species of chipmunks, deer mice, western jumping mice, vagrant shrews, and others. Numerous species of birds (about 34) are known to breed in the upper montane forest. Insects, especially leafhoppers, are abundant. The lower montane forest is similar in nature to the upper. The animals found in both areas are very similar. The dominant trees are somewhat different. Douglas-fir, blue spruce, limber pine, white fir, and ponderosa pine are the dominant vegetation. Mountain ash, Rocky Mountain maple, ninebark, bearberry, and other shrubs are found in the lower stratum. In the lower reaches of this forest ruffed grouse, purple martins, red-breasted nuthatches, and western tanagers are found. Insects are similar to those of the higher forest - leafhoppers and Diptera. These insects live primarily in the canopy and provide much of the food for birds. The effects of man are apparent, especially in the montane forest where the timber is harvested. At lower elevations there is some farming of wheat and hay. Sheep and cattle are grazed in the meadows and clearings.

The aquatic ecosystems in this reach of the river include the river itself and its tributaries. The gradient is steep and the current is rapid. Water temperatures are cold, the source being melting snow. Aquatic plants are mainly diatoms tolerant of the cooler water. Insect nymphs and larvae are the predominant insect life with Diptera and Ephemeroptera being well represented. Trout may live in these cooler blowing waters. Alpine lakes, located at altitudes greater than 10,000 feet are characterized by a paucity of aquatic biota due to the harsh conditions. The lakes in this region (elevation 8,000-10,000 feet) which drain into the river are good examples of hydrarch succession, their ultimate end being peat bogs and meadows. The water is very cold and slightly acid. The lakes are stratified thermally and have low dissolved oxygen because of the low temperatures. Floating, rooted plants (Nymphaea) are found at the edge; planktonic algae and rooted, submerged plants are found in the open water areas.

Insect larvae and adults are found in these lakes. Some fish (trout and other coldwater species) may occur naturally or be stocked in these lakes. The cold temperatures and low oxygen, slow decomposition and dead organic material will gradually fill in a lake. Wet meadows are then formed with sedges such as Carex and mosses like Sphagnum predominating. As dead organic material continues to accumulate, the ground level is built up above the water table and the area may become suitable for the montane forests described above. At lower elevations (to 7,000 feet) the densities of both plants and animals in both lakes and streams increase as conditions become less severe.

The Bear River continues flowing northward from Evanston, Wyoming, to Soda Springs, Idaho, where it turns southward. The gradient in this region is much less than upstream (7,000 feet to about 5,900 feet). The river makes numerous small meanders in this stretch and picks up a sediment load from surrounding land. Over much of this distance to Soda Springs the river valley floor is broad and flat. Numerous ridges and high plateaus, seldom exceeding 8,000 feet in elevation, border both sides of this valley.

On the valley floor farmland predominates since the soils are fertile and water can be obtained from the river. Wheat, oats, barley, alfalfa, clover, and wild hay are the primary crops. Yields are moderate. Cottonwoods and willows may line the river banks. Bunchgrasses and sagebrush are the natural vegetation of the valley floor. The area, of course, is disturbed and mammals are not extremely common. Cottontails and jackrabbits may be found as well as chipmunks and mice. Insects are very common, with beetles and bugs (Hemiptera) often reaching high densities in the crops. As the elevation increases from the valley floor, bushland is encountered. Characteristic plants are deciduous oaks and Cercocarpus. Many animals use this area. Mule deer may be common during portions of the year. Smaller mammals include the weasel, skunk, Uinta ground squirrel, jumping mice, golden-mantled ground squirrel, marmot, and many others.(21) Birds are also common. Scrub jay, steller's jay, black-headed grosbeak, mourning dove, birds of prey (hawks, owls, eagles), pheasants, quail, and many species of over-wintering birds. This ecosystem is important in providing wintering grounds for migrants from further north. This bushland generally extends to elevations near 8,000 feet. Those areas at higher elevations have the characteristic lower montane forests described above.

The aquatic environment is typical of fairly rapid rivers. The water is cool and at least some portions of this reach can support self-sustaining populations of rainbow and cutthroat trout. The plants are plankton (diatoms) which occur in larger numbers than those found near the headwaters and attached algae (periphyton). Insect nymphs and larvae are present. Marshland occurs in several places along this portion of the river.

Especially large tracts occur just north of Bear Lake. Rooted vegetation in these marshes is cattails and bulrushes. Carex may also occur. Numerous waterfowl, especially ducks and Canada geese, use these marshlands. Skunks and weasels may use this area also, preying on bird eggs and other organisms. Muskrats are also found. Insects, especially midges and other diptera are common in the marshes. Bear Lake is a deep, oligotrophic lake with low productivity. Mackinaw and bonneville cisco are found in the lake in sufficient numbers to provide good sport fishing. Aquatic insects, especially dipterans, are common and provide the food base for these fish.

At the northern end of the Wasatch Range, near Soda Springs, Idaho, the Bear River turns southward, flowing along a course generally parallel to its northward course upstream. The Wasatch and Bear River Ranges border the river valley on the east and lower ridges and hills border on the west. The Wasatch Mountains may reach elevations of 10,000 feet, while the western ridges and hills seldom exceed 8,000 feet. The gradient of the river is relatively flat from the Soda Spring (5,900 feet) to the Great Salt Lake (4,200 feet). The river meanders through most of this region. Its course straightens as it passes through Oneida Narrows. The sediment load carried in this portion of the river is large. Basically, the river flows through three wide valleys - Gem Valley, Cache Valley, and Bear River Valley. Canyons or narrows connect the valleys.

The terrestrial ecosystems adjacent to this stretch of the Bear River are similar to those described in the previous paragraph. The valley floors are somewhat broader and are mostly cropland. The soil is quite fertile and water for irrigation is supplied by the river and its tributaries. Crops include wheat, alfalfa, barley, corn, and many others. Yields from irrigated lands are quite good for this region. The region disturbed by farming does not generally harbor large populations of wildlife, except those species which feed on the crops. The species found are the same as described for the upstream river valley floor. Pheasants are especially abundant in some areas. To the east of the valley the mountains rise quickly from the valley floor. Distinct bands of vegetation starting with the sagebrush-bunchgrass community at the lower elevations are found. Weasels, skunks, several species of mice, jackrabbits, cottontails, and other mammals are common. Lazuli bunting, mourning dove, black-headed grosbeak, and species of upland game birds such as pheasant and quail are found. The distinct communities above this are in order of increasing altitude, bushland, lower montane forest, and in some areas the upper montane forest. On the west where elevations seldom exceed 8,000 feet, the sagebrush-bunchgrass and bushland communities are predominant.

The aquatic community for the river between Oneida Narrows and the Great Salt Lake changes slightly from that described for the upstream reaches. The increased sediment load has reduced water quality and consequently the variety of species and biomass of the aquatic biota. Trout and other sport fish (whitefish) are generally present in small numbers, while suckers, Utah chubs, and carp (in some areas) are common. The tributaries flowing into the Bear River, particularly those from the Wasatch Mountains, are cold and clear for at least the upper portions of their course. The biota found in these streams are the same as those described for the headwaters of the Bear River The larger tributaries, the Malad and Little Bear Rivers, are similar to the Bear River. The marshlands, located along the river and its tributaries, are similar to those found in the upper reaches of the river.

At the mouth of the Bear River is the Bear River Migratory Bird Refuge. This refuge accommodates huge numbers of both migrant and resident waterfowl. Because of the high quality of the habitat, it is an important aquatic ecosystem in the Bear River Drainage. The vegetation of the marshland consists of several plants. Salicornea rubra is found in areas where there is still a high salt concentration. Alkali bulrush is common in areas of less salt and provides the best nesting and food materials. Management of the area includes programs to prevent other less desirable species such as cattails, hardstem bulrush, and saltgrass from becoming dominant. Animals include muskrats, weasels, skunks, and others. The latter species, especially, can destroy sufficient numbers of waterfowl if densities are very high. Carp and catfish are present in large numbers. The insects are common. The midges are especially abundant providing food both for aquatic organisms and the waterfowl.

Numerous species of waterfowl occur. From the dabbling duck group gadwalls, pintail, American widgeon, shoveler, green-winged teal, blue-winged teal, cinnamon teal, and mallard are the most common. The redhead, goldeneye, canvasback, bufflehead, and others are the major diving ducks using the refuge. Ruddy ducks, Canada geese, western grebe, stilts, avocets, killdeer, willet, sandpipers, phalaropes, and others are also common. The whistling swan uses the refuge both in the fall and spring as a stopover on its migratory flight. California gulls also nest on the site. Other songbirds and less common waterfowl and shorebirds also use the refuge. Because of the large area capable of accommodating millions of birds and the high quality of the habitat, this refuge is an important marshland for resident or nesting species, as well as the migrant birds.

Selection of Oneida Narrows and Honeyville Segments

Because a primary objective of the research was the field testing of the EES and not a complete Environmental Impact Analysis of the Bear River Project, only part of the Bear River Project was investigated in detail. Segments selected for analysis are representative of other Bureau of Reclamation projects and provide a "good" testing of the EES.

Selection of the locations for the field test was a two-step procedure. First, the Battelle-Columbus research team spent one week in the field gathering general information on the Bear River. Included in this trip was an airplane flight over the entire basin and a drive to all segments of the project. This trip was followed by discussions with Bureau of Reclamation personnel. The two sites selected for the field test were: (See Figure 78, a foldout in the back of the report.)

(1) Oneida Narrows
(2) Honeyville.

Information Used in Analysis

Because some details on the Oneida Narrows and Honeyville segment had not been developed, it was necessary, in some cases, to make assumptions about the segments and, in other cases, to omit consideration of potential changes. General assumptions that were made on both segments were:

- Construction practices normally used by the Bureau would also be used in the development of these segments
- Management of the fish and wildlife resources and recreation areas would be acceptable
- Each reservoir would have one vertical flow release point
- Each reservoir would exhibit drawdowns throughout the year
- Physical and chemical effects in the streams and reservoirs would be similar to those produced by the construction of previously developed reservoirs
- Land purchased by the Bureau of Reclamation around reservoirs would conform to the existing 300-foot guideline
- Future municipal and industrial water uses in the Soda Springs area (Oneida Narrows) would be for residential consumption and for the

phosphate industry. Future municipal and industrial water uses were omitted from analysis in the Honeyville segment for lack of information

- Effluents from residential and industrial developments, both water and air, would conform to state standards.

Specific information on the Oneida and Honeyville segments was obtained from the following sources:

(1) "Bear River Investigations, Status Report, June 1970"(20)

(2) "Bear River Project First Phase, Idaho and Utah", June 1965(22)

(3) "Bear River Project: Parts I and II, July 1962"(23)

(4) Bureau of Reclamation personnel.

Information on the environmental quality in the Bear River Basin was obtained from:

(1) On-site evaluations

(2) Federal, state, and local agencies

(3) Universities

(4) Literature.

For a list of contributors to the field testing phase, see Acknowledgments.

FIELD TEST OF ONEIDA NARROWS SEGMENT

The Oneida Narrows segment would provide a 435,000 acre-feet reservoir formed by a 315-foot dam. The proposed reservoir would extend 32-river miles upstream from the dam, inundating an existing hydroelectric dam (30,000 kw) and about 1,400 acres of irrigated land in the Gentile and Gem Valleys (see Figure 78). The stored water would be distributed by gravity flow through a 75-mile canal to the Cache and Malad Valleys for irrigation and other uses. Additional irrigation service from this water amounts to 88,600 acres.

The Oneida Narrows Reservoir would also be used to improve the fish, wildlife, and recreation resources in the area. Coulam National Wildlife Refuge would be established in Franklin County, Idaho, on 4,693 acres of land, and the Condie, Twin Lakes, and Newton Reservoirs which are currently being used for irrigation would become potential fishery pools. A trout fishery is also expected below the Oneida Narrows Dam.

Availability of water in the Oneida Narrows Reservoir would, by exchange, allow for the supply of 20,000 acre-feet of water for municipal and industrial requirements in the Soda Springs - Montpelier area. This water would be used primarily for future residential and phosphate industry development in the area.

A summary of the uses of the water from the Oneida segment is given in Table 4.

TABLE 4. WATER USES: ONEIDA NARROWS

Water Use	Annual Estimate, acre-feet
Irrigation	177,200
Fish and Wildlife	
3 Reservoirs	7,300
Coulam Refuge	12,000
Municipal and Industrial	20,000
TOTAL	216,500

Step 1. Define the Boundaries for the Study

Bureau Responsibility

Environmental impacts from Oneida Narrows that can be attributed to the Bureau of Reclamation are given below.

- Construction – All direct and indirect impacts on environment from construction of the reservoir and canal
- Use – All direct impacts from
    - (a) Operation of reservoir
    - (b) Irrigation
    - (c) Municipal and industrial development
    - (d) Fish and wildlife
    - (e) Recreation
    - (f) Flood control.

Spatial and Temporal Considerations

Oneida Narrows was evaluated for environmental pollution, esthetics, and human interest impacts according to the spatial breakdown given below. (See Figure 78, a foldout in the back.)

- Upstream – Just south of Montpelier, Idaho, to the backwater of Oneida Narrows Reservoir
- Reservoir Site – Backwater of the reservoir to the dam site
- Transfer - 75-mile canal and adjacent areas
- Downstream – Oneida Narrows site to Bear River Migratory Bird Refuge including the Malad River drainage area.

For the ecological analysis these spatial areas were grouped into counties:

- Franklin County, Idaho
- Oneida County, Idaho
- Caribou County, Idaho
- Box Elder County, Utah
- Cache County, Utah.

Although counties are not the best unit for ecological analysis, the ecological data was available in this format.

The temporal considerations used in the "with" project evaluations of Oneida Narrows were (a) during construction of the project and (b) during use of the project.

Step 2. Obtain Data Measurements

A work sheet was filled out for each parameter in the EES. Because of space limitations these worksheets are not included in the report. For an example of the measurements that went into the worksheet see Figure 75.

Step 3. Determine EIU

As in Step 2, it is not possible to show for all parameters the computations that are needed to transform the measurements on the work sheet to the final EIU. Selected examples have been used to illustrate the transformation process for Oneida Narrows.

Ecology

Crops. The magnitude times a quality technique was used for evaluating this parameter. First, appropriate project boundaries were set. Because of the long canal and other actions by the Bureau located at some distance from the actual impoundment (i.e., Coulam Refuge), the project boundaries were set at the portions of Caribou, Franklin, and Oneida Counties, Idaho, and Box Elder and Cache Counties, Utah, included in the Bear River Drainage. The total arable land within these boundaries was 610,000 acres which was equated with 100 percent on the value function. The acreage of the three types of arable land was determined "without" the project:

TABLE 5. TYPE, AREA, AND PRODUCTIVITY OF ARABLE LAND AT ONEIDA NARROWS "WITHOUT" THE PROJECT

Type	Area	Productivity
Irrigated	268,700 acres	5380 lb/acre/yr
Dry Farm	225,600 acres	1500 lb/acre/yr
Grazed	115,700 acres	615 lb/acre/yr

The average annual production was estimated from the U. S. Census of Agriculture(24) (for irrigated and dry farm) and from Fundamentals of Ecology by E. P. Odum(25). These productivity values were intermediate on the productivity scale on page 17 so interpolation between the two appropriate levels for each productivity value was done. The irrigated acreage production was weighted at 0.92, the dry farm production at 0.38, and the grazed land at 0.15. The acreage of each type was multiplied by the appropriate weight, divided by the 610,000 acres of arable land and multiplied by 100, to give the following weighted percents:

Irrigated -	41%
Dry farm -	14%
Grazed -	3%
TOTAL	58%

The total, 58%, was the parameter value "without" the project.

The Bureau proposes to irrigate 88,600 additional acres from Oneida Narrows. Assuming that it is dry farm which will be irrigated, 88,600 acres must be subtracted from the dry farm area and added to the irrigated area*; production for each type is assumed to remain the same.

TABLE 6. TYPE, AREA, AND PRODUCTIVITY OF ARABLE LAND AT ONEIDA NARROWS "WITH" THE PROJECT

Type	Area	Productivity
Irrigated	357,300 acres	5380 lb/acre/yr
Dry Farm	137,000 acres	1500 lb/acre/yr
Grazed	115,700 acres	615 lb/acre/yr

A small area of arable land inundated at the northern end of the proposed impoundment was ignored as being insignificant (compared to the total acreage used in crops). Had that acreage been greater, it would have been subtracted from the appropriate type but not from the total arable land. This insures that arable land lost is adequately measured. Multiplying these new acreages (Table 6) by the appropriate weights, dividing the product by 610,000 acres, and multiplying by 100 gives the parameter value with the project:

Irrigated -	54%
Dry farm -	9%
Grazed -	3%
TOTAL	66%

Thus, a net positive change of .08 EQ units** is predicted at Oneida Narrows.

Environmental Pollution

Total Dissolved Solids. Total dissolved solids (TDS) is an excellent illustrative example for the Oneida analysis because of TDS increases expected to result from additional irrigation in the Bear and Malad River Basins. A total of approximately 89,000 acres of full and supplemental service lands will be put into service as a result of the Oneida Project. Further, it has been estimated that in the Bear River Basin TDS loadings to surface waters are about 0.6 tons/acre irrigated/year whereas in the Little Malad River, TDS loadings average about 2.0 tons/acre irrigated/year.(26)

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*Actually, over half (49,000 acres) of the land to receive water from the project is already partially irrigated. The benefits to these lands will be smaller than those to dry farmland which becomes full service land because of the project.

**Because there is a 1:1 relationship between the percent and EQ for this parameter, 58 percent and 66 percent are equal to 0.58 and 0.66 EQ, respectively.

Data on the Bear and Little Malad Rivers indicate that average TDS levels in the Bear River are in the neighborhood of 500 mg/l from above Bear Lake down to Cutler Reservoir, at which point the level rises rapidly peaking at 4,000-5,000 mg/l at the Bird Refuge.(27-30) Based on limited data it is estimated that TDS levels in the Malad River range from 1,000-6,000 mg/l.

For purposes of predicting increases in the TDS levels, the additional acreage to be irrigated was aggregated into four main tracts and it was assumed that return waters were discharged at four discrete points as follows:

Point No.	Acres	Location	Assumed Point of Return Flow Discharge
1	30,000	Bear River above Large Oneida, south of Grace Power Plant	Midway between Grace Power Plant and northern limit of proposed Large Oneida Reservoir
2	11,000	Bear River between Clifton, Idaho, and Weston, Idaho	South of Preston, Idaho
3	13,000	Bear River between Clarkston and Newton, Utah	Cutler Reservoir
4	35,000	Malad River between Samaria, Idaho, and Plymouth, Utah	North of Plymouth, Utah

Increases in TDS resulting from flows from each of the four above areas are as follows:

Area	Increase in TDS (mg/l)
1	11
2	7
3	7
4	1,000

The next step in conducting the analysis was to decide how to weigh different effects in the upstream, reservoir site, and downstream areas. Because the major areas to be affected are downstream of the irrigated areas and because the most sensitive areas to TDS - the Bird Refuge - is downstream, the following weightings were employed:

Upstream	0.10
Reservoir Site	0.10
Downstream	0.80

Because the TDS levels are considerably different at the three major downstream areas – i.e., at the Bird Refuge, in the other portions of the Bear River, and in the Malad River, it was necessary to treat each of these areas separately in the analysis. Separate values or ratings were calculated for each of these downstream areas, and were then assigned the following portions of the 0.80 weighting used for downstream areas:

Bird Refuge	0.28
Bear River	0.40
Malad River	0.12
Total Downstream	0.80

Using data contained on the work sheet and in EQ values from the TDS value functions, the following overall rating was calculated for the "without" the project condition:

Spatial Component	EQ x Importance = Score
Upstream	1.0 x 0.10 = 0.10
Reservoir Site	1.0 x 0.10 = 0.10
Downstream	
Bear River	0.95 x 0.40 = 0.38
Bird Refuge	0.07 x 0.28 = 0.02
Malad River	0.00 x 0.12 = 0.00
	0.60

Using data contained on the work sheet, the TDS profiles and the TDS value function, the following overall rating was calculated for the "with" project condition:

Spatial Component	EQ (at TDS) x Importance = Score
Upstream	1.0 (at TDS = 511.5) x 0.10 = 0.10
Reservoir Site	1.0 (at TDS = 511.5) x 0.10 = 0.10
Downstream	
Bear River	0.94 (at TDS = 1025) x 0.40 = 0.37
Bird Refuge	0.05 (at TDS = 2565) x 0.28 = 0.01
Malad River	0.00 (at TDS > 3000) x 0.12 = 0.00
	0.58

Esthetics

Relief and Topographic Character. The Oneida Narrows segment included various types of topography. For this reason the "Relief and Topographic Character" parameter is a good example to illustrate esthetic evaluation.

Within the proposed Oneida Narrows Reservoir there are three distinct sections: the lower canyon, Mound Valley plus the existing reservoir, and Gentile Valley. The lower canyon section is approximately three miles long, extending from a point one-half mile downstream from the proposed dam site upstream, to the southern end of Mound Valley.

The canyon wall rises from the valley floor to an elevation of about 4,680 feet to 5,700 feet on the east side and slightly less on the west. This is a relief of between 900 feet and 1,100 feet, defined by canyon walls of craggy, vertical rock formations, interspersed with smoother surface formations. A high esthetic rating was given to the canyon without the proposed reservoir. Much of the craggy and irregular rock formation is close to the valley floor and would be inundated by the proposed 300-foot deep reservoir. Much of the unique rock formations would be covered, and the visual depth of the canyon would be decreased by 300 feet. Because of the loss of depth and the loss of interesting rock formation on the canyon wall, the proposed reservoir will substantially lower the esthetic rating.

The second section composed of the three-mile long Mound Valley, plus the eight-mile long existing reservoir, is not as exciting or stimulating as the lower canyon, from the viewpoint of relief and topographic character. The relief averages 600 feet and the slopes are much smoother than those of the lower canyon. Using a relief value of 600 feet plotted against a point between the smooth and irregular value curves, an esthetic EQ of 0.35 results.

The proposed reservoir will effectively lower the visual height of the slopes defining Mound Valley, and will slightly affect the depth of a cross section through the existing reservoir. For this reason the esthetic value on this parameter will be slightly less "with" the proposed reservoir than "without" it.

The third area of distinct topographical character at the proposed Oneida Narrows Reservoir is the 11- to 12-mile-long section of the reservoir that will be in the Gentile Valley.

Within a horizontal distance of a half mile from the proposed reservoir, there is from 100- to 400-foot relief. The surface of the surrounding hills is smooth. The esthetic value resulting from these two factors is low. The proposed reservoir in

Gentile Valley would affect the relief and topographic values very little, so the "with" and "without" values are the same.

Gem, Cache, and Malad Valleys within the Oneida Narrows segment are generally similar to the Gentile Valley as far as this parameter is concerned, and were therefore rated the same.

Total aggregated values for the "without" project and "with" project conditions are:

"Without" Project

Spatial Component	EQ x Importance = Score
Upstream	0.15 x 0.05 = 0.008
Reservoir Site	
Lower Canyon	0.85 x 0.28 = 0.238
Mound Valley	0.35 x 0.05 = 0.017
Gentile Valley	0.15 x 0.22 = 0.033
Downstream	
Malad Valley	0.15 x 0.25 = 0.037
Cache Valley	0.15 x 0.10 = 0.015
	Total EQ = 0.348 (0.35)

"With" Project

Spatial Component	EQ x Importance = Score
Upstream	0.15 x 0.05 = 0.008
Reservoir Site	
Lower Canyon	0.60 x 0.28 = 0.168
Mound Valley	0.25 x 0.05 = 0.013
Gentile Valley	0.15 x 0.22 = 0.033
Downstream	
Malad Valley	0.15 x 0.25 = 0.037
Cache Valley	0.15 x 0.10 = 0.015
	Total EQ = 0.274 (0.27)

Human Interest

Employment Opportunities. For an evaluation of the impacts that the Oneida Narrows project would have on employment opportunities, it seemed appropriate to consider the three sectors, Downstream, Reservoir, and Upstream. The employment opportunities in each of these sectors may be affected by the project. It is difficult to predict the degree to which the effects may occur; however, the trend of effects can be predicted.

Each sector was assigned a percentage weight to indicate the importance of impacts within that sector. The reservoir sector was assigned 60% in the case of Oneida Narrows because of the direct impacts on the employment opportunities in this sector. The other two sectors, Downstream and Upstream, were assigned equal importance of 20% each.

Each sector was given an "existing" rating of .70. They were rated .70 rather than .80 because the areas are somewhat developed (.70), but not highly developed (which .80 would indicate).

The reservoir sector was given a "with" rating of .30. This rating was based on the fact that much of the established farming, business, and service patterns in Gentile Valley would be disrupted.

The downstream sector was rated .80 – a small improvement over the existing situation. At this time, it is questionable as to whether the increase in available water for irrigation would result in more employment opportunities for farmers, or whether the same number of farmers who are now in the downstream sector would be using the additional water.

The project description predicts an increase in water for industrial uses in the upstream sector (Soda Springs area). If this is so, the result would most likely be an increase in employment opportunities in that area. Therefore, the upstream sector was given a rating of .90 in the "with" evaluation – an improvement of the existing situation.

A weighting of the "without" and "with" the project follows.

"Without" Project

Spatial Components	EQ x Importance = Score
Upstream	0.7 x 0.2 = 0.14
Reservoir	0.7 x 0.6 = 0.42
Downstream	0.7 x 0.2 = 0.14
	Total EQ = 0.70

"With" Project

Spatial Components	EQ x Importance = Score
Upstream	0.9 x 0.2 = 0.18
Reservoir Site	0.3 x 0.6 = 0.18
Downstream	0.8 x 0.2 = 0.16
	Total EQ = 0.52

"With" and "Without" Evaluations

The final "with" and "without" EIU for each parameter for Oneida Narrows is given from Table 7 to 10. These tables are grouped by the four major categories.

TABLE 7. ENVIRONMENTAL EVALUATION OF ONEIDA NARROWS: ECOLOGY

Parameter	Weight (PIU)	With (EIU)	Without (EIU)	Change (EIU)
Species and Populations				
[Terrestrial]				
Browsers and Grazers	14	14.00	14.00	0.00
Crops	14	9.24	8.12	+1.12
Natural Vegetation	14	5.88	5.88	0.00
Pest Species	14	*	*	(0)
Upland Game Birds	14	ND	ND	--
[Aquatic]				
Commercial Fisheries	14	0.00	0.00	0.00
Natural Vegetation	14	11.48	11.62	-0.14
Pest Species	14	*	*	(-1.4)
Sport Fish	14	5.74	4.90	+0.84
Waterfowl	14	12.04	12.04	0.00
Habitats and Communities				
[Terrestrial]				
Food Web Index	12	6.00	6.00	0.00
Land Use	12	10.08	10.20	-0.12
Rare and Endangered Species	12	3.60	3.60	0.00
Species Diversity	14	ND	ND	--
[Aquatic]				
Food Web Index	12	ND	ND	--
Rare and Endangered Species	12	10.80	10.80	0.00
River Characteristics	12	6.72	8.52	-1.80
Species Diversity	14	ND	ND	--
Total[1]		95.58	95.68	-0.10

* - No Quantitative Information: Estimated Change.

ND - No Data.

[1] - Total does not include estimated changes.

TABLE 8. ENVIRONMENTAL EVALUATION OF ONEIDA NARROWS: ENVIRONMENTAL POLLUTION

Parameter	Weight (PIU)	With (EIU)	Without (EIU)	Change (EIU)
Water Pollution				
Basin Hydrologic Loss	20	15.80	17.00	-1.20
BOD	25	18.00	21.25	-3.25
Dissolved Oxygen	31	29.45	31.00	-1.55
Fecal Coliforms	18	5.40	9.00	-3.60
Inorganic Carbon	22	21.34	21.34	0.00
Inorganic Nitrogen	25	24.50	24.50	0.00
Inorganic Phosphate	28	2.80	5.04	-2.24
Pesticides	16	*	*	(0)
pH	18	7.20	9.00	-1.80
Stream Flow Variation	28	19.32	8.68	+10.64
Temperature	28	4.20	8.40	-4.20
Total Dissolved Solids	25	14.50	15.00	-0.50
Toxic Substances	14	0.00	0.00	(0)
Turbidity	20	7.00	5.00	+2.00
Air Pollution				
Carbon Monoxide	5	*	*	(0)
Hydrocarbons	5	*	*	(0)
Nitrogen Oxides	10	*	*	(0)
Particulate Matter	12	*	*	(0)
Photochemical Oxidants	5	*	*	(0)
Sulfur Oxides	10	*	*	(0)
Other	5	*	*	(0)
Land Pollution				
Land Use	14	12.18	11.90	+0.28
Soil Erosion	14	13.02	13.44	-0.42
Noise Pollution				
Noise	4	*	*	(0)
Total[1]		194.71	200.55	-5.84

* - No Quantitative Information; Estimated Change.

1 - Total does not include estimated changes.

TABLE 9. ENVIRONMENTAL EVALUATION OF ONEIDA NARROWS: ESTHETICS

Parameter	Weight (PIU)	With (EIU)	Without (EIU)	Change (EIU)
Land				
Geologic Surface Material	6	1.50	1.86	-0.36
Relief and Topographic Character	16	4.32	5.60	-1.28
Width and Alignment	10	3.10	4.30	-1.20
Air				
Odor and Visual	3	2.55	2.55	0.00
Sounds	2	0.72	0.92	-0.20
Water				
Appearance of Water	10	3.10	3.70	-0.60
Land and Water Interface	16	5.92	4.82	+1.12
Odor and Floating Materials	6	3.48	3.78	-0.30
Water Surface Area	10	3.80	0.50	+3.30
Wooded and Geologic Shoreline	10	2.30	2.30	0.00
Biota				
Animals - Domestic	5	2.20	2.10	+0.10
Animals - Wild	5	1.95	2.30	-0.35
Diversity of Vegetation Types	9	4.77	5.31	-0.54
Variety Within Vegetation Types	5	1.80	1.85	-0.05
Man-Made Objects				
Man-Made Objects	10	5.80	6.70	-0.90
Composition				
Composite Effect	15	7.65	8.25	-0.60
Unique Composition	15	0.90	2.85	-1.95
Total		55.86	59.67	-3.81

TABLE 10. ENVIRONMENTAL EVALUATION OF ONEIDA NARROWS: HUMAN INTEREST

Parameter	Weight (PIU)	With (EIU)	Without (EIU)	Change (EIU)
Educational/Scientific Packages				
Archeological	13	ND	ND	--
Ecological	13	7.54	6.37	+1.17
Geological	11	2.75	3.52	-0.77
Hydrological	11	2.20	1.10	+1.10
Historical Packages				
Architecture and Styles	11	0.00	0.00	0.00
Events	11	6.60	6.60	0.00
Persons	11	0.00	0.00	0.00
Religions and Cultures	11	0.00	0.00	0.00
"Western Frontier"	11	0.00	0.00	0.00
Cultures				
Indians	14	0.00	0.00	0.00
Other Ethnic Groups	7	0.00	0.00	0.00
Religious Groups	7	0.00	0.00	0.00
Mood/Atmosphere				
Awe-Inspiration	11	3.74	6.82	-3.08
Isolation/Solitude	11	5.06	7.04	-1.98
Mystery	4	0.88	1.60	-0.72
"Oneness" With Nature	11	3.30	6.82	-3.52
Life Patterns				
Employment Opportunities	13	6.76	9.10	-2.34
Housing	13	4.42	9.10	-4.68
Social Interactions	11	5.50	7.70	-2.20
Total[1]		48.75	65.77	-17.02

ND - No Data.

[1] - Total does not include estimated changes.

Step 4. Determine "Red Flags"

"Red flags" for problem areas and for data needs were determined for Oneida Narrows. Identification of the "red flags" was based on the four rules discussed in a previous section of the report.

Problem Areas - Minor Flags

The minor problem "red flags" are listed in Table 11. Each of these flags is discussed in the narrative below.

TABLE 11. RED FLAGS FOR ONEIDA NARROWS: PROBLEM AREAS

Minor Flags	Major Flags
Environmental Pollution BOD pH	Ecology Aquatic Pest Species River Characteristics
Esthetics Width and Alignment Sounds	Environmental Pollution Fecal Coliforms Temperature
Human Interest Isolation/Solitude Employment Opportunities Social Interactions	Esthetics Unique Composition
	Human Interest Awe-Inspiration Mystery "Oneness" with Nature Housing

BOD. The primary effect on BOD in the Bear River that will result from the Oneida Narrows Project will occur at the reservoir site. The condition at the site "without" the project is that of a relatively swift moving stream and a small reservoir. "With" the project, the entire site will be in a reservoir condition. Since reservoirs cannot assimilate as high levels of BOD as swift streams, Oneida Narrows may create BOD problems in the reservoir. No BOD effects are predicted upstream or downstream of the reservoir site.

pH. Levels of pH in the portion of the Bear River related to the Large Oneida Project average about 8.5. Since the soil in the area is alkaline, some increase in pH would be expected due to the pick-up of alkalinity by irrigation return flows. It was estimated that average pH might rise to 8.7 as a result of this effect.

Width and Alignment. A significant lowering of the esthetic quality will result in the lower Oneida Narrows Canyon if the proposed reservoir is constructed. The lower canyon area extends three miles downstream from the dramatic entrance through a vertical rock formation at the south end of Mound Valley to a point one-half mile downstream from the proposed dam site.

In many sections of this portion of the canyon the valley floor is very narrow, only wide enough for a narrow dirt road and the river. Often the rock walls for the first several hundred feet above the elevation of Bear River are nearly vertical, resulting in a visual impression of deep, narrow cross-section. A three hundred foot deep reservoir will eliminate approximately one-third or more of the apparent depth of the canyon. More importantly, it will inundate many of the steeper rock formations which are close to the valley floor.

Traveling along the banks of the Bear River through this three mile portion of the canyon, numerous sharp bends and angles are encountered. The effect of this tortuous alignment stimulates interest both psychologically and esthetically. Much of this mystery and interest will be lost by the several hundred foot wide proposed reservoir. The character of the canyon will change from a tortuous to a meandering, almost straight, alignment.

The "red flag" results from reducing the apparent depth of the lower canyon as well as smoothing the alignment. The EQ rating for this parameter of other areas in the Oneida Narrows segment, such as Malad, Cache, Gem Gentile, Mound Valley, and the existing hydroelectric reservoir will not be appreciably altered by the proposed reservoir.

Sounds. Walking through the lower three miles of the Oneida Narrows Canyon there is the constant, sometimes gentle, sometimes boisterous, natural sound of water flowing and splashing over rocks. The loss of this stimulating sound of free flowing water will result in a lower Environmental Quality rating. It is true that the Oneida Narrows Reservoir will also result in an increase in the sound of bird life that will be attracted by the additional land to be irrigated; however, in the judgment of the evaluator, using the sound criteria illustrated by Figure 52, the loss of the free flowing Bear River sound in the canyon will be greater than the gain of the occasional sound of birds and other animal life resulting from the proposed irrigation.

Isolation/Solitude. The area below the present dam was considered to be high in isolation and solitude; it is accessible only by a dirt road, and is used predominantly by fishermen. The location of the present dam is even more inaccessible than the above area, but there are a few homes which house the employees of the power plant, therefore it is not as high in isolation. Above the present dam is even lower in isolation/solitude because of the presence of farms, farming activities and roads.

In the "with" situation, the area below the present dam was considered to have lost many of the qualities that contribute to the feeling of isolation/solitude; the location of the present dam would also diminish in the feeling of isolation/solitude because this area would probably have an increase in the number of recreational activities. It was anticipated that no change would occur in the area above the dam.

Employment Opportunities. See pages 144-145 for a complete explanation of this "red flag".

Social Interactions. The effects on social interactions were determined for three sectors - downstream, reservoir, and upstream. The existing situation in each sector was rated the same. The "with" situation for downstream improved because it was felt that, with additional people coming into the area, there would be increased opportunities for social interactions. However, the reservoir sector diminished in environmental quality because there would be disruption, to varying degrees, to interactions resulting from clubs, friendships, schools, churches, and shopping and travel patterns. The upstream sector is anticipated to experience improvement as in the downstream sector. The overall change was negative but only to a minor degree as is noted by this flag.

Problem Areas - Major Flags

The major red flags are listed in Table 11. Each of these flags is discussed in the narrative below.

Aquatic Pest Species. The negative change in Aquatic Pest Species is a result of two factors. The first was the regulation of the Bear River downstream from the proposed dam and impoundment. The water level in the river without the impoundment fluctuates seasonally. The seasonal fluctuations reflect the large input of water in the spring and early summer as the snow melts. During other seasons input from precipitation and melting snow is small and the water level in the river correspondingly low.

The seasonally fluctuating water level tends to prevent the establishment and growth of "water-pumping" plants, phreatophytes along the banks of the stream. These plants, with their roots exposed to the moist soil at the stream's bottom and their above-ground portions exposed to the high intensity sunlight characteristic of higher altitude, arid or semi-arid regions, are capable of evaporating or transpiring large volumes of water from the stream or river into the atmosphere. Because of this characteristic, these plants are considered undesirable (weeds). Without an impoundment to reduce the seasonal water level fluctuations, these plants cannot become established along the river due to the scouring action of the water at high levels and the lack of water at low levels. With the impoundment the river flow downstream from the dam will be better regulated. The water level fluctuations will be reduced and the opportunity for the undesirable phreatophytes to become established will be increased.

In addition to the increased chance for the establishment of phreatophytes, there will be an increased area (when compared to the natural river) of shallow water around the perimeter of the impoundment. This area will permit the growth of phreatophytes and provide a productive area (littoral zone) where sunlight penetration and nutrient levels and oxygen are high. Such areas are conducive to rapid plant growth or blooms (of algae) which can reduce sunlight penetration and tie up valuable nutrients within the plant biomass. As the plants die their decomposing bodies can cause a reduction in water quality, thus influencing other aquatic and terrestrial organisms using this shallow area.

River Characteristics. The change with the impoundment represents the inundation of 432 acres of running water. This is a loss of habitat for organisms requiring the flowing water environment. Some of these organisms are desirable sport fish. Because of the tendency to create more and more impoundments in this area for water regulation purposes, the acreage of flowing water is decreasing. Its value both to organisms capable of living only in flowing water and to people deriving recreational benefits from these organisms is constantly increasing. The effect of inundating 432 acres by the proposed impoundment is moderated somewhat by the fact that the quality of that water for organisms and recreational use is only intermediate.

Fecal Coliforms. Fecal coliforms in the Oneida Narrows area currently average about 1,000 MPN/100 ml. As a result of additional municipal water use at Soda Springs and possible recreation use of the reservoir site, it is estimated that coliform levels upstream and at the site may reach 3,000 MPN/100 ml "with" the project.

Temperature. Temperature in the Oneida Narrows area currently averages about 4 C above natural conditions. Due to a slight warming of irrigation water, it is estimated that average temperature levels will rise to 5 C above natural conditions.

Unique Compositions. The only area of the Oneida Narrows segment that is sufficiently unique to be evaluated by this parameter is the three mile lower Oneida Narrows Canyon area. The possible loss of this canyon from the construction of the proposed reservoir would result in a downgrading of the EQ.

It is recognized that there are hundreds of canyons in the western states; however, those sites with major rivers flowing through them are becoming fewer each decade.

Throughout its water course of approximately five hundred miles, the Bear River has carved two major canyons, the Oneida Narrows and the smaller canyon downstream at Wheelon Station. The Cutler Dam has eliminated the latter canyon. This river, rising in the Wasatch Mountain Range in Utah, is a clean, sparkling stream for miles. Later, it flows through Wyoming and Idaho for several hundred miles as a meandering, slow flowing, relatively turbid stream. It is not until it reaches the Oneida Narrows Canyon that the character of the stream and its surrounding topography changes dramatically. For only in these three miles of the approximately five hundred mile length of the river does it still flow through an exciting, tortuous canyon with craggy rock walls. While this canyon may not be classified as a rare topographic configuration, it is an unusual composition for the Bear River project area. Its loss would be a pronounced negative change in the EQ value of this important parameter.

If a conscious effort is not made to protect and preserve the esthetic stimulation of this unusual type of natural environment, major river canyons may soon become "rare and endangered natural areas".

Awe-Inspiration. In the "without" evaluation, the area below the present dam was rated high because of the deep, narrow canyon; the area located at the present dam was rated medium because the canyon is partially filled by the reservoir, but there is still a sense of being surrounded by high, fairly steep hills; the area above the present reservoir was also rated medium. The latter area consists of a wide-sweeping valley surrounded by distant mountains.

The "with" evaluation resulted in the area below the present dam being rated low because this part of the canyon would be filled with water and therefore the depth of the canyon which produced the sense of awe-inspiration would no longer exist. No change was anticipated at the present dam. It was anticipated that there would be a positive effect in the area above the present reservoir because of the presence of a large body of water.

The overall evaluation, however, was major in the negative direction because of the loss of the canyon.

Mystery. Of the three areas in the Oneida Narrows reservoir site, only the area below the present dam has any element of mystery about it. By building the dam most of the deep part of the canyon would be inundated, and, therefore, almost all of the mystery would be lost.

"Oneness" With Nature. Because of the atmosphere of peacefulness and closeness in the canyon below the present reservoir site, it was rated low-high in the "without" situation. In the "with" situation this same area would be covered with water; therefore, the source of the feeling of "oneness" with nature would be lost. Both other areas were rated as being average in the "without" evaluation. However, for the "with" evaluation, it was felt that the creation of recreational opportunities in both areas would increase the likelihood of more people, noise, and activity in those areas; therefore, both areas were rated somewhat lower.

Housing. For the evaluation of this parameter, the three areas identified as possibly being affected were (1) reservoir site, (2) downstream, and (3) upstream. The existing situation in the reservoir site is rated as an average of the "existing", because it is a fairly high populated area for a rural farming area. The "without" situation was rated as a high disruption of existing because creating the reservoir would necessitate the relocation of many families from their present homes. It is anticipated that there would be no changes in Areas 2 and 3.

Data Needs - Red Flags

The data used in the environmental evaluation of Oneida Narrows were taken primarily from published information, although for some of the ecology parameters "file" data were used. For this reason some of the data gaps found in this analysis could be filled by several months in the field using unpublished information.

The areas where data gaps were found are listed in Table 12.

TABLE 12. RED FLAGS FOR ONEIDA NARROWS: DATA NEEDS

Ecology
    Terrestrial Pest Species
    Upland Game Birds
    Aquatic Pest Species
    Terrestrial Species Diversity
    Aquatic Food Web Index
    Aquatic Species Diversity

Environmental Pollution
    Pesticides
    Carbon Monoxide
    Hydrocarbons
    Nitrogen Oxides
    Particulate Matter
    Photochemical Oxidants
    Sulfur Oxides
    Other Air Pollution
    Noise

Human Interest
    Archeological

Terrestrial Pest Species. Data on kinds of terrestrial pest species occurring in an area as well as the proportion of the area within the project boundaries inhabited or used by the pests are needed. These data on pests are probably available from the appropriate local, state, and Federal government agencies, as well as local universities.

Upland Game Birds. Good estimates of the absolute or (more likely) relative densities of the upland game birds are needed for the Oneida Narrows area. Also, the optimum or maximum desirable density which the various habitats can support are needed. Density estimates for species currently inhabiting the area and the maximum supportable density must be comparable. These data are required for the density modifier used in measuring the parameter. State fish and game agencies or local universities should be able to supply these data.

Aquatic Pest Species. The data needed here are the same kinds as those needed for Terrestrial Pest Species given above. Sources for this data are also the same.

Terrestrial Species Diversity. Species diversity data for many western communities have not been measured. Such measurements need to be obtained. Plant diversity should be measured for at least three basic communities surrounding the site:

(1) Valley floor

(2) Foothills

(3) Higher mountains.

To determine diversity, both the number of species and the density (coverage, frequency, or some other estimate) for each for the dominant plant stratum (tree stratum for forest, shrub stratum for foothills, etc.) need to be measured. Often state fish and game agencies may have at least some of these data. However, in most cases the data will have to be acquired in the field.

Aquatic Food Web Index. Good absolute or relative estimates of the densities of animals in the important aquatic food webs in the rivers or streams in the area are needed. Local universities are most likely to have this information available. State fish and game agencies may supply some fish density information. The estimates for the densities of the members of the food web must be comparable. Relative and absolute densities should not be mixed, if possible.

Aquatic Species Diversity. The measurements needed here are the kinds and densities of the benthic organisms located in the river upstream from the proposed impoundment, at the proposed impoundment, and downstream from the impoundment. Local universities may have collected such data for some of the areas although field sampling will probably be required in other areas.

Pesticides. At the present time this information is not being gathered in the Oneida Narrows area. Agencies responsible for the data collection do not "expect" it to be a problem.

Air Parameters. At the present time, air pollution data are not being measured in the rural area near Oneida Narrows.

Noise. Data are not presently being gathered on noise in the Oneida Narrows area. Noise is not expected to be a problem.

Archeological. Several of the areas near Oneida Narrows have been surveyed for archeological information. At the present time only general information on the Oneida Narrows area is known by the archeologists in the area.

Ecosystems Affected

The ecological boundaries established for the Oneida Narrows include those portions of Franklin, Caribou, and Oneida Counties in Idaho and Box Elder and Cache Counties in Utah which are in the Bear River drainage. Within these boundaries there are more than 1.6 million acres of land and water surface. This land is distributed among a variety of ecosystems. Those ecosystems are the lower montane forest, the bushland, the valley floor terrestrial systems, including both cropland and natural bunchgrass grassland, standing and running water ecosystems, and marshlands. The general characteristics of these systems have been described in the section on the ecosystems of the Bear River drainage basin. It is appropriate here to elaborate those descriptions for the systems actually affected by the Oneida Narrows project.

The lower montane forest is found along the eastern portion of the project area in the Wasatch and Bear River Ranges. Elevations occasionally reach 10,000 feet, but most of this area is 8,000 feet or less. Large areas of the higher montane forest do not occur. There are some scattered tracts of lower montane forests west of the Bear River itself. The dominant species of the lower montane forest are Douglas fir, blue spruce, white fir, ponderosa pine, and limber pine. The shrub stratum of these forests may include mountain ash, ninebark, Rock Mountain maple, and bearberry. Approximately 500,000 acres are in forestland within the project boundaries. The annual production of these forests is about 4,000-6,000 pounds per acre. In areas where the forest is dense, large mammals are not commonly found. In less dense regions mule deer and some elk are found during portions of the year. Small mammals are abundant and include yellow-haired porcupine, striped skunk, Uinta ground squirrel, pocket gopher, snowshoe hare, chipmunks, deer mice, red squirrel, western jumping mice, and shrews. Many species of birds either feed and/or nest in the lower montane forest. Ruffed grouse, purple martins, red-breasted nuthatches, and western tanagers are common. Forest grouse occur in some areas. Leafhoppers are the most common insects, with species of Diptera ranking next in abundance. Open areas in the forest and meadows are used for the grazing sheep and perhaps some cattle.

The bushland community occurs on the lower slopes of the mountains, ridges, and ranges within the project boundaries. Scrub oak and Cercocorpus are frequently found along with other plants. Annual plant productivity is 600 to 750 pounds per year. Mule deer frequent this area during portions of the year. The deer herds in this region number about 23,000 deer. Small mammals such as the Uinta ground squirrel, weasel, golden-mantled ground squirrel, jumping mice, and many others live in this ecosystem. Birds include the scrub jay, Stellar's jay, black-headed grosbeak, hawks, eagles, owls, and other birds which spend the winter in the bushland. Numerous upland game birds are found. The mourning dove is common with the chukar, sage grouse, quail, and pheasant also in the area.

The valley floor is primarily an agricultural community. Within the project boundaries there are about 268,700 acres irrigated, 225,600 acres dry farmed, and about 115,700 acres grazed. Wheat, alfalfa, oats, and barley are the major crops. The productivities of the three types of agricultural land are 5,400 lb/acre, 1,500 lb/acre, and 600 lb/acre, respectively. The grazed land is dominated by sagebrush and bunchgrass (Agropyron, cheat grass, grama grasses). In moderate to heavily grazed areas plant coverage is about 40 to 50 percent, with sagebrush the most common plant. In lightly grazed or ungrazed areas, the bunchgrasses become common along with the sagebrush. Coverage here is as much as 70 to 75 percent. Weeds such as Canada thistle, Dyerswood, and other thistles occur in the area and are quite dense in some places. Plant diseases include rusts, smuts, molds, and root rots. Large mammals are domestic cattle and sheep. There are about 100,000 Animal Units using the area. Chipmunks, mice, cottontails, and jackrabbits are common small mammals. Insects are common and may damage crops when their numbers are especially large. Beetle larvae and hemiptera are particularly troublesome. Birds include the horned lark, Brewer's sparrow, starlings, magpies, English sparrows, sage thrasher, and several birds of prey (burrowing owl, marsh hawk, eagles). Pheasant are common and sharptailed grouse are found. Ticks, cattle lice, stableflies, hornflies, and some others are pest species.

The aquatic ecosystems include both standing and running water. In the ponds and reservoirs aquatic life does not do especially well because of problems with fluctuating water levels and high silt concentrations. Carp and other trash fish are found. Lost Chance Reservoir is stocked with rainbow and cutthroat trout (about 3,000 annually) and is one of the better reservoirs as far as aquatic life is concerned.

The Bear River is the major riverine ecosystem in the Oneida Narrows area. The river has a relatively low velocity, cool water, and a high sediment load. Aquatic life in the river is quite variable in both species composition and density, depending on the season of the year. Phytoplankton are generally diatoms or green algae and range in numbers from 250 cells per ml to as many as 11,000 cells per ml during algal bloom. Benthic organisms include insect larvae, crustaceans (Gammarus), snails, and others. Many other larvae are abundant. Density of benthos may average from less than 50 to 300 individuals per square feet. About 35,000 cutthroat and rainbow trout are stocked in the Oneida Narrows portion of the Bear River annually. A few tributaries to the

Bear River such as Blacksmith's Fork are good natural fish producing areas, because trout can reproduce in some numbers in these areas.

Areas of marshland occur along the Bear River or its tributaries. Approximately 285,000 acres of marshland occur within the boundaries. Most of it (270,000 acres) occur in Utah near the mouth of the Bear River. Much of the acreage is prime habitat harboring much aquatic life, waterfowl, shore birds, mammals, and song birds. The Bear River Refuge, comprising about 65,000 acres (25,000 acres developed) produced annually about 45,000 young ducks and 2,500 young geese. The ducks visiting or nesting include dabblers (gadwall, several teals, shoveler, baldpate, mallard, and pintail) and divers (redhead, goldeneye, lesser scaup, canvasback, and bufflehead). The Canada goose nests in the Refuge; other geese only visit. Whistling swans, western grebe, black-necked stilt, American avocet, willet, sandpiper, killdeer, and numerous other species use the Refuge as well as other marshlands. The food for these birds includes both insects and plants. The midge larvae are found in great numbers in the marshlands. Vegetation is varied but the marshland is often managed to maintain alkali bulrush which provides the best food and nesting material. Other plants include cattails, ogo pardweed, saltgrass, and hardstem bulrush. Carp and catfish are found in the water, often in great numbers. Weasels, skunks, and muskrats use the marshland, the first two preying on the waterfowl. California gulls may be common and cause a problem by eating waterfowl eggs. The primary disease organism is Clostridium botulinum (botulism, type E).

The net impact on the ecosystems of Oneida Narrows is negligible. This impact results from the balancing of the positive and negative changes that would be expected from the development of the Oneida Narrows site. This measurement of impact on the ecosystem is supported by the negligible changes predicted by a more quantitative evaluation made for the population and community components of the ecosystem. These components are more sensitive to change than the whole system.

Step 5. Report Information in EES Summary

A summary of the "with" and "without" evaluations and the number and distribution of the "red flags" is given in Table 13.

The net environmental impact from the development of Oneida Narrows as indicated by the ecology category was adverse but small in magnitude. This low negative value is the result of a balance of beneficial changes as measured by crops and sport

TABLE 13. EES SUMMARY: ONEIDA NARROWS

SECTION I: VALUE OF IMPACT IN EIU

Category	Quantitative Change: With Project	Quantitative Change: Without Project	Quantitative Change: Difference	Qualitative Change Estimate	Net Change
Ecology	96	96	0	-1	-1
Environmental Pollution	195	201	-6	0	-6
Esthetics	56	60	-4	0	-4
Human Interest	49	66	-17	0	-17
Total	396	423	-27	-1	-28

SECTION II: NUMBER OF RED FLAGS: PROBLEM AREAS AND DATA NEEDS

Category	Component	Problem Areas: Minor	Problem Areas: Major	Data Needs
Ecology	Species and Populations	0	1	3
	Habitats and Communities	0	1	3
Environmental Pollution	Water Pollution	2	2	1
	Air Pollution	0	0	7
	Land Pollution	0	0	0
	Noise Pollution	0	0	1
Esthetics	Land	1	0	0
	Air	1	0	0
	Water	0	0	0
	Biota	0	0	0
	Man-Made Objects	0	0	0
	Composition	0	1	0
Human Interest	Educational/Scientific Packages	0	0	1
	Historical Packages	0	0	0
	Cultures	0	0	0
	Mood/Atmosphere	1	3	0
	Life Patterns	2	1	0
Total		7	9	16

fish with the adverse changes created by the enhancement of the aquatic pest species and the loss of the habitat for free floating organisms.

A similar balance exists in the environmental pollution category. The significant improvement in the rivers' flow variation (reduction in man-made variation) and turbidity is countered by an increase in the rivers' temperature, pH, inorganic phosphate, BOD, evaporation, and reduction in dissolved oxygen. The net impact again is negative but only small in magnitude.

The esthetic category also has a small negative net environmental impact. In this category the beneficial improvements as measured by the amount of water surface area available and the reduction of drawdown created by the reservoirs fluctuation is countered by a number of small losses. The major loss concerns the flooding of the only remaining canyon on the Bear River.

The most significant environmental impact is in the Human Interest category. Significant impacts on the social environment are created by the loss of the canyon and the major disruption of the farming community. Improvements in the educational/scientific packages resulting from the new reservoir do not outweigh the losses.

The total net environmental impact is negative but minor in magnitude.

The "red flags" listed in the second section of the Summary Table correspond to the adverse impacts discussed above. They have all been discussed in the preceding pages.

FIELD TEST OF HONEYVILLE SEGMENT

The Honeyville segment would have a reservoir with a capacity of 120,000 acre-feet (105,000 acre-feet active) formed by a 76-foot dam. The proposed reservoir would extend 25 miles upstream to the Cutler Power Plant inundating about 3,800 acres of land. The reservoir water would be used primarily to manage the Bear River flow into the Bear River Migratory Bird Refuge. About 68,000 acre-feet would be used on an annual basis in the regulation of the river.

The reservoir would be used to provide readily accessible water-based recreation for the area. Also, a firm supply of 30,000 acre-feet of water annually would be available to satisfy municipal and industrial needs in southern Box Elder County, Utah.

A summary of the water uses from the Honeyville segment is given in Table 14.

TABLE 14. WATER USES: HONEYVILLE

Water Use	Annual Estimate, acre-feet
Flow Regulation	68,000
Municipal and Industrial	30,000
TOTAL	98,000

Step 1. Define the Boundaries for the Study

Bureau Responsibility

Environmental impacts from Honeyville that can be attributed to the Bureau of Reclamation are given below:

- Construction - All direct and indirect impacts on the environment from the construction of the reservoir
- Use - All direct impacts from
    - (a) Operation of reservoir
    - (b) Regulation of river flow
    - (c) Municipal and industrial development
    - (d) Recreation
    - (e) Fish and wildlife.

Spatial and Temporal Considerations

Honeyville was evaluated for environmental pollution, aesthetics, and human interest according to the breakdown given below (see Figure 78 foldout in the back):

- Upstream – Backwater of Cutler Power Dam to backwater of Honeyville
- Reservoir Site – Backwater of reservoir to the dam site
- Transfer - Not applicable
- Downstream – Honeyville Dam to Bear River Migratory Bird Refuge.

For the ecological analyses these spatial areas were grouped into counties:

- Box Elder County, Utah
- Cache County, Utah.

Although counties are not the best unit for ecological analysis, the ecological data were available in this format.

The temporal considerations used in the "with" project evaluations of Honeyville were (a) during construction of the project and (b) during use of the project.

Step 2. Obtain Data Measurements

A work sheet was filled out for each parameter in the EES. Because of space limitations these work sheets are not included in the report. For an example of the measurements that went into the work sheet, see Figure 75.

Step 3. Determine EIU

As in Step 2, it is not possible to show for all parameters the computations that are needed to transform the measurements on the work sheet to the final EIU. Selected examples have been used to illustrate the transformation process for Honeyville.

Ecology

Crops. Boundaries for this proposed project were set at the area of Box Elder County, Utah, within the Bear River Drainage Basin. Water from the project would be used within these boundaries. The total arable land was 158, 800 acres. The acreage and the productivity of the types of farming done on this land and the weight of each type (obtained by interpolation using the modifier scale for productivity) without the project are given in Table 15.

TABLE 15. TYPE, AREA, PRODUCTIVITY, AND WEIGHT OF ARABLE LAND AT HONEYVILLE "WITHOUT" THE PROJECT

Type	Area	Productivity	Weight
Irrigated	66,200 acres	5380 lb/acre/yr	0.92
Dry Farm	32,200 acres	1500 lb/acre/yr	0.38
Grazed	60,400 acres	615 lb/acre/yr	0.15

Calculations using these data were performed as for Oneida Narrows: area of type times the weight of type's productivity, divided by 158,800 acres, and multiplied by 100. The results are

Irrigated - 38%
Dry farm - 8%
Grazed - 6%
TOTAL - 52%

None of the water available "with" the project will be used for irrigation. However, there will be approximately 1,426 acres of irrigated land inundated by the project (1,926 surface acres of water impounded minus the 500 surface acres of water already present in the river). This acreage must be subtracted from the 66,200 acres of irrigated land to give 64,774 acres of irrigated land "with" the project. All other acreages, including the total arable land, remain the same. The results of the calculations "with" the project are:

Irrigated - 38%
Dry farm - 8%
Grazed - 6%
TOTAL 52%

Thus, there is no detectable change "with" the project indicating that the impact upon crops at Honeyville is insignificant.

Environmental Pollution

Stream Flow Variation. The following analysis of the effects of the Honeyville Reservoir on stream flow has been selected for illustration because it is an example of how Bureau projects can benefit the environment. Specifically, construction of the Honeyville Reservoir would significantly dampen fluctuations in river flow that are presently caused by power releases from Cutler Reservoir. In conducting the analysis it was assumed that release patterns from Cutler may be characterized by release patterns from the existing small Oneida Narrows Reservoir, which is also a hydroelectric plant; the reason for this is that the release data from the existing Oneida Reservoir were available whereas data from the Cutler were not. It was also assumed that releases from the proposed Honeyville Reservoir could be characterized by those from Woodruff Narrows – another nonhydroelectric reservoir for which data were available. Using the value functions, the analysis of these two reservoir conditions proceeds as follows:

- To characterize the flow downstream of a power dam, five years of daily flow records at the existing Oneida plant were examined. A basically regular pattern was observed in that daily variations of approximately 40:1 were observed; further, these flow variations occur by and large in a period of approximately two hours each day. Using the value functions described in Figures 31-34, the overall rating is calculated as follows:

$$0 \text{ days with } \frac{\text{Daily Max.}}{\text{Daily Min.}} \leq 2:1 \rightarrow f_1 = 0.8$$

$$0 \text{ days with } \frac{\text{Daily Max.}}{\text{Daily Min.}} \leq 10:1 \rightarrow f_2 = 0.7$$

$$100\% \text{ of days with } \frac{\text{Daily Max.}}{\text{Daily Min.}} \leq 50:1 \rightarrow f_3 = 0.7$$

$$\text{with } \Delta t = 2 \text{ hrs.}$$

$$\text{Score} = f_1 \times f_2 \times f_3 = 0.392.$$

- To characterize flow below a nonhydroelectric dam, as will be the case below the proposed Honeyville Dam, stream flow records below Woodruff Narrows were reviewed and analyzed. In so doing, it was determined that the flow could be characterized as follows:

$$95\% \text{ of the days with } \frac{\text{Daily Max.}}{\text{Daily Min.}} \leq 2.1$$

$$\text{with } \Delta t = 24 \text{ hours} \qquad \rightarrow f_1 = 1.0$$

$$100\% \text{ of the days with } \frac{\text{Daily Max.}}{\text{Daily Min.}} \leq 10.1$$

$$\text{with } \Delta t = 2 \text{ hours} \qquad \rightarrow f_2 = 0.75$$

$$\text{Score} = f_1 \times f_2 = 0.75$$

- In aggregating the analysis of the changed condition expected to result from the Honeyville feature, conditions at the upstream, reservoir site, and downstream locations were weighted as follows:

Upstream	0.1
Reservoir Site	0.1
Downstream	0.8

Total aggregated scores for the "without" project and "with" project conditions are as follows:

"Without" Project

Spatial Component	EQ x Importance = Score
Upstream	1.0 x 0.1 = 0.10
Reservoir Site	0.39 x 0.1 = 0.04
Downstram	0.39 x 0.8 = 0.31
	Total EQ = 0.45

"With" Project

Spatial Component	EQ x Importance = Score
Upstream	1.0 x 0.1 = 0.10
Reservoir Site	1.0 x 0.1 = 0.10
Downstream	0.75 x 0.8 = 0.60
	Total EQ = 0.80

Esthetics

Land and Water Interface. The existing power plant at the Cutler Reservoir can cause severe changes of elevation of many feet in one day on the section of the Bear River where the proposed Honeyville Reservoir would be located. If the reservoir is constructed, the effect of the Cutler Power Plant will be moderated. The result would be a higher rating on this parameter at the reservoir, on the Bear River below the proposed dam, and to a lesser extent in the Bear River Migratory Bird Refuge.

Total aggregated values for the "without" project and "with" project conditions are:

"Without" Project

Spatial Component	EQ x Importance = Score
Upstream	0.0 x 0.0 = 0.0
Reservoir Site	0.3 x 0.85 = 0.26
Transfer	0.0 x 0.0 = 0.0
Downstream	
Bear River	0.3 x 0.10 = 0.03
Bird Refuge	0.7 x 0.05 = 0.035
	Total EQ = 0.325 (0.33)

"With" Project

Spatial Component	EQ x Importance = Score
Upstream	0.0 x 0.0 = 0.0
Reservoir Site	0.6 x 0.85 = 0.51
Transfer	0.0 x 0.0 = 0.0
Downstream	
Bear River	0.6 x 0.10 = 0.06
Bird Refuge	0.9 x 0.05 = 0.045
	Total EQ = 0.615 (0.62)

Human Interest

"Western Frontier". The Honeyville site has one area that is of significant historical interest. The area applies to the parameter "Western Frontier" because it is not related to a specific person or event, but is significant to the history of the settlement of the West. The area of significance includes the site of one of the earliest fording places (Hampton's Ford) across the Bear River, used by Indians and settlers, the Holladay Overland Mail Route, and the Pony Express Trail. The same site was used for a toll ferry to cross the river from 1853 to 1859. In 1859 a bridge was built and was used until the present bridge was built in 1892.

Also on the site is the Hampton's Ford Stage Stop built in 1866 which still stands in good condition. This was used as a hotel by stage travelers. Across the road from the hotel is the Hampton's Ford Stage Station Barn built soon after 1866.

This package of occurrences of historical interest was labeled an external package because it appears to be of interest to more people than just those in the "internal" area.

Referring to the value function for Historical External Packages, the value of this package was rated Low-Medium, thus having an Environmental Quality value of .70. The value given the package was based on the following considerations:

(1) The site contains the combination of an historical fording place, ferry crossing, and bridge crossing of the Bear River, a hotel and a barn, used by stage passengers and Pony Express riders, both still standing, with few changes in original structure.

(2) The area has been designated a Utah State Historic Site by the Utah State Historical Society.

(3) Both the house and barn have been recorded in the Historic American Buildings Survey.

(4) The setting of the buildings, river, and road to the fording place and bridge is the same as it was 100 years ago.

(5) Application has been made to the National Register of Historic Places for the site to be included in the register.

The Environmental Quality value given this package in a "with" evaluation is .0. The sites of the fording place, bridge, house, barn, and road leading to the bridge would all be inundated and lost. The buildings could possibly be moved to another site; however, the setting of the buildings is a very important aspect of the integrity of the site, therefore, a new setting would not be of nearly as much historical value.

"With" and "Without" Evaluations

The final "with" and "without" EIU for each parameter for Honeyville is given from Table 16 through Table 19. These tables are grouped by the four major categories.

Step 4. Determine "Red Flags"

"Red flags" for problem areas and for data needs were determined for Honeyville. Selection of the "red flags" was based on the four rules discussed in a previous section of the report.

Problem Areas - Minor Flags

The minor problem "red flags" are listed in Table 20. Each of these flags is discussed in the narrative below.

Sport Fish. The change in sport fish represents the replacement of a river of moderate value as a sport fish area with an impoundment of lesser value. Carp and other undesirable fish are expected to increase in the impoundment at the expense of more desirable sport species.

Land Use. The Honeyville project area is currently 100 percent developed but with a low density of development. It is estimated that construction of the reservoir will promote additional development, primarily in the form of recreational and related support activities, to the medium-low level.

TABLE 16. ENVIRONMENTAL EVALUATION OF HONEYVILLE: ECOLOGY

Parameter	Weight (PIU)	With (EIU)	Without (EIU)	Change (EIU)
Species and Populations				
[Terrestrial]				
Browsers and Grazers	14	5.32	4.90	+0.42
Crops	14	7.28	7.28	0.00
Natural Vegetation	14	3.36	3.36	0.00
Pest Species	14	*	*	(0)
Upland Game Birds	14	8.26	8.26	0.00
[Aquatic]				
Commercial Fisheries	14	0.00	0.00	0.00
Natural Vegetation	14	11.20	11.20	0.00
Pest Species	14	5.88	5.88	0.00
Sport Fish	14	3.50	3.78	-0.28
Waterfowl	14	11.20	11.20	0.00
Habitats and Communities				
[Terrestrial]				
Food Web Index	12	ND	ND	--
Land Use	12	10.32	10.32	0.00
Rare and Endangered Species	12	3.60	3.60	0.00
Species Diversity	14	ND	ND	--
[Aquatic]				
Food Web Index	12	ND	ND	--
Rare and Endangered Species	12	10.80	10.80	0.00
River Characteristics	12	*	*	(-6)
Species Diversity	14	ND	ND	--
Total[1]		80.72	80.58	+0.14

* - No Quantitative Information: Estimated Change.

ND - No Data.

1 - Total does not include estimated changes.

TABLE 17. ENVIRONMENTAL EVALUATION OF HONEYVILLE: ENVIRONMENTAL POLLUTION

Parameter	Weight (PIU)	With (EIU)	Without (EIU)	Change (EIU)
Water Pollution				
Basin Hydrologic Loss	20	16.80	17.00	-0.20
BOD	25	11.50	18.00	-6.50
Dissolved Oxygen	31	27.90	29.45	-1.55
Fecal Coliforms	18	5.40	5.40	0.00
Inorganic Carbon	22	21.34	21.34	0.00
Inorganic Nitrogen	25	24.50	24.50	0.00
Inorganic Phosphate	28	5.04	5.04	0.00
Pesticides	16	*	*	(0)
pH	18	12.06	12.06	0.00
Stream Flow Variation	28	22.40	12.60	+9.80
Temperature	28	16.80	16.80	0.00
Total Dissolved Solids	25	13.50	13.50	0.00
Toxic Substances	14	0.00	0.00	(0)
Turbidity	20	5.00	4.00	+1.00
Air Pollution				
Carbon Monoxide	5	*	*	(-0.25)
Hydrocarbons	5	*	*	(-0.25)
Nitrogen Oxides	10	*	*	(-0.5)
Particulate Matter	12	*	*	(-0.6)
Photochemical Oxidants	5	*	*	(-0.25)
Sulfur Oxides	10	*	*	(-0.5)
Other	5	*	*	(0)
Land Pollution				
Land Use	14	8.40	11.20	-2.80
Soil Erosion	14	13.02	13.30	-0.28
Noise Pollution				
Noise	4	*	*	(-0.2)
Total[1]		203.66	204.19	-0.53

* - No Quantitative Information: Estimated Change.

1 - Total does not include estimated changes.

TABLE 18. ENVIRONMENTAL EVALUATION OF HONEYVILLE: ESTHETICS

Parameter	Weight (PIU)	With (EIU)	Without (EIU)	Change (EIU)
Land				
Geologic Surface Material	6	1.02	1.02	0.00
Relief and Topographic Character	16	0.64	0.64	0.00
Width and Alignment	10	2.60	2.60	0.00
Air				
Odor and Visual	3	1.77	2.04	-0.27
Sounds	2	0.52	0.52	0.00
Water				
Appearance of Water	10	3.20	3.80	-0.60
Land and Water Interface	16	9.92	5.28	+4.64
Odor and Floating Materials	6	3.84	4.56	-0.72
Water Surface Area	10	4.70	0.90	+3.80
Wooded and Geologic Shoreline	10	2.60	2.60	0.00
Biota				
Animals - Domestic	5	2.95	3.20	-0.25
Animals - Wild	5	1.70	2.10	-0.40
Diversity of Vegetation Types	9	5.31	6.12	-0.81
Variety Within Vegetation Types	5	1.70	2.35	-0.65
Man-Made Objects				
Man-Made Objects	10	5.10	5.10	0.00
Composition				
Composite Effect	15	8.85	5.10	+3.75
Unique Composition	15	0.00	0.00	0.00
Total		56.42	47.93	+8.49

TABLE 19. ENVIRONMENTAL EVALUATION OF HONEYVILLE: HUMAN INTEREST

Parameter	Weight (PIU)	With (EIU)	Without (EIU)	Change (EIU)
Educational/Scientific Packages				
Archeological	13	*	*	(-2.60)
Ecological	13	10.40	9.10	+1.30
Geological	11	ND	ND	--
Hydrological	11	*	*	(0)
Historical Packages				
Architecture and Styles	11	0.00	0.00	0.00
Events	11	0.00	0.00	0.00
Persons	11	0.00	0.00	0.00
Religions and Cultures	11	0.00	0.00	0.00
"Western Frontier"	11	0.00	7.70	-7.70
Cultures				
Indians	14	0.00	0.00	0.00
Other Ethnic Groups	7	0.00	0.00	0.00
Religious Groups	7	0.00	0.00	0.00
Mood/Atmosphere				
Awe-Inspiration	11	0.00	0.00	0.00
Isolation/Solitude	11	2.31	3.96	-1.65
Mystery	4	0.00	0.00	0.00
"Oneness" with Nature	11	2.86	3.96	-1.10
Life Patterns				
Employment Opportunities	13	6.76	7.80	-1.04
Housing	13	5.46	7.80	-2.34
Social Interactions	11	4.84	6.60	-1.76
Total[1]		32.63	46.92	-14.29

* - No Quantitative Information: Estimated Change.

ND - No Data.

1 - Total does not include estimated changes.

TABLE 20. RED FLAGS FOR HONEYVILLE: PROBLEM AREAS

Minor Flags	Major Flags
Ecology	Ecology
Sport Fish	River Characteristics
Environmental Pollution	Environmental Pollution
Land Use	BOD
Esthetics	Human Interest
Odor and Floating Materials	"Western Frontier"
Variety Within Vegetation Types	Isolation/Solitude
	Housing
Human Interest	
Archeological	
"Oneness" With Nature	
Social Interactions	

Odor and Floating Materials. The Bear River at the site of the proposed Honeyville Reservoir, in its present "without" condition, was rated very high, on the EQ scale. A slightly lower projected rating was given for the "with" situation.

The lower projected rating was based on observation of numerous existing impoundments; for example, the hydroelectric reservoir in the upper Oneida Narrows Canyon, where some scum, logs and algae are evident in the surface of some inlets and bays. It is also anticipated that the Honeyville Reservoir will receive heavy boating use. Similar to other bodies of water where this type of use is extensive, it is probable that some oil scum will be evident on heavy-use weekends.

Variety Within Vegetation Types. The present plant composition of the proposed Honeyville Reservoir site is crops and a few trees on the level land on each side of the shallow winding river valley of fifty to one hundred feet deep and approximately two to four hundred feet wide. Growing on the flood plain of the valley are numerous deciduous river trees which add variety to the esthetic composition. The proposed reservoir would inundate these river bank trees and the visual appeal from the plant variety viewpoint will be reduced.

Archeological. Archeologists familiar with the Bear River Basin stated that there has been no archeological study made of the proposed reservoir site. However, there have been archeological "finds" in the river basin below Honeyville. It was assumed that there would be similar archeological information in the Honeyville area.

"Oneness" With Nature. The proposed reservoir site was evaluated as being low medium in its present state. There is an element of peacefulness in this area, but the surroundings are not conducive to producing an intense feeling of "oneness" with nature. It is expected that this peaceful state would be somewhat reduced by the recreational development proposed for the area. The additional people noise, and activity would reduce the feeling of "oneness" with nature.

Social Interactions. The social interactions of the existing situation were considered to be low in value. Development of the reservoir would create a medium disruption to the existing social patterns.

Problem Areas - Major Flags

The major "red flags" are listed in Table 20. Each of these flags is discussed in the narrative below.

River Characteristics. About 500 acres of flowing water will be inundated by the impoundment. The reasons for this change are the same as those given for this parameter for the Oneida Narrows where it also was a major problem area.

BOD. Construction of the Honeyville reservoir will change the condition of the site from that of a stream to that of a reservoir. Because reservoirs cannot assimilate as high levels of BOD as streams, the construction of the Honeyville reservoir may precipitate BOD problems in the reservoir. No BOD effects are predicted upstream or downstream of the reservoir site.

"Western Frontier". This parameter package consists of the Hampton's Ford which includes a house, barn, trail, bridge, and former fording place, all of which are of historical interest. All are located within the proposed reservoir site. In a "with" situation, the Hampton's Ford site would be inundated; therefore, there would be significant change in this parameter. For more explanation of the change in this parameter see discussion on page 168.

Isolation/Solitude. The area around the Honeyville site is sparsely settled. Much of the area of the proposed reservoir site is somewhat isolated simply because of the sparse population. One aspect of the proposed project is to develop the reservoir for recreation. The net result of recreational development will be a decrease in the degree of isolation/solitude present in the area.

Housing. The reservoir site was given 100 percent weight in the parameter housing because it is the only area in the Honeyville project where housing will be affected. The existing housing situation in the reservoir site was rated low because the area is sparsely populated. It is expected that the disruption to the existing situation will be significant enough to be expressed as a "red flag".

Data Needs – Red Flags

The data used in the Environmental Evaluation of Honeyville were taken primarily from published information, although for some of the ecology parameters "file" data were used. For this reason some of the data gaps found in this analyses could be filled by several months in the field using unpublished information.

The areas where data gaps were found are listed in Table 21.

TABLE 21. RED FLAGS FOR HONEYVILLE:
DATA NEEDS

- Ecology
  - Terrestrial Pest Species
  - Terrestrial Food Web Index
  - Terrestrial Species Diversity
  - Aquatic Food Web Index
  - River Characteristics
  - Aquatic Species Diversity

- Environmental Pollution
  - Pesticides
  - Carbon Monoxide
  - Hydrocarbons
  - Nitrogen Oxides
  - Particulate Matter
  - Photochemical Oxidants
  - Sulfur Oxides
  - Other Air Pollution
  - Noise

- Human Interest
  - Archeological
  - Geological
  - Hydrological

Terrestrial Pest Species. The same data as described for Oneida Narrows will be needed for the Honeyville Pest Species. Data sources are the same.

Terrestrial Food Web Index. Relative or absolute densities for the important terrestrial food webs are needed. For this parameter only the animal densities are needed. The estimates obtained must be comparable - relative and absolute densities should not be mixed. State fish and game agencies as well as local universities should be able to supply much of the data.

Terrestrial Species Diversity. The number of plant species and their densities for the dominant plant stratum needed to be measured as described for Oneida Narrows. Field work will probably be needed for this parameter.

Aquatic Food Web Index. The data needed and the sources should be the same as for those described for Oneida Narrows.

River Characteristics. The data needed for this parameter for Honeyville are good estimates of the quality modifier types of the streams and rivers. This involves information of the water temperature and water flows. The source will be the Utah Fish and Game Department who are preparing such data for publication in 1972. Other states are also providing these data.

Aquatic Species Diversity. The measurements, using benthic organisms, are exactly the same as those described for this parameter for Oneida Narrows. Local universities may be able to supply some of these data, but some field work will probably be required.

Pesticides. The data problem for Honeyville is similar to the problem for Oneida Narrows.

Air Pollution. The data problem for Honeyville is similar to the problem for Oneida Narrows.

Noise. The data problem for Honeyville is similar to the problem for Oneida Narrows.

Archeological. There have been no archeological surveys conducted on the Honeyville segment of the Bear River.

Geological. There have been no published geological investigations of the area included in the Honeyville segment. This data probably does not exist.

Hydrological. Published data are lacking for the Honeyville area. A detailed investigation of the area by the research team did not produce any information.

Ecosystems Affected

The ecological boundaries for the Honeyville project are much smaller than those for Oneida Narrows. They encompass only that portion of Box Elder County, Utah, which is in the Bear River Drainage. This area was also included in the boundaries for the Oneida Narrows project; the descriptions of the ecosystems affected for that project also apply to Honeyville. However, some of the details are different for Honeyville.

Higher montane forests may be found in the highest portions of the Bear River Range which lies on the eastern side of this area. The species found are those described in the general description of the Bear River drainage basin ecosystems. Annual forest productivity will average 4,000 to 6,000 pounds per acre. Deer and perhaps elk and bighorn sheep may feed in the less dense portions of these forests. Lower montane forests cover larger areas at lower elevations and are the same as those described for Oneida Narrows. There are only about 24,000 acres of forestland within the Honeyville boundaries. Forest grouse, one of the upland game birds in the lower montane forest, are not very abundant. Hunter harvest data indicate only 70-200 birds are taken annually.

The bushland community is much the same as that described for Oneida Narrows. Essentially no deer reside completely within that portion of Box Elder County within the Bear River drainage basin. Some deer do use at least portions of this area during parts of the year. Mourning doves are quite numerous. Hunters annually bag 3,000 to 6,000 birds. A few hundred sage grouse and quail are also taken. Chukar partridge are hunted, the numbers taken ranging from 2,000 to 4,000 birds annually.

The description of the valley floor ecosystem is the same for Honeyville as for Oneida Narrows except the acreages are smaller for Honeyville. About 66,000 acres of irrigated cropland, 32,000 acres of dry farmland, and 60,000 acres of grazed land are found within the Honeyville boundaries. Cattle and sheep are the most important domestic animals. About 5,000 Animal Units are present in this portion of Box Elder County. Pheasant, the most common upland game bird, is abundant. The annual hunter kill is 4,000 to 8,000 birds.

The aquatic ecosystems are the same as those described for Oneida Narrows. There is little or no stocking of fish in the Bear River or its tributaries which lie within the project boundaries. Carp and catfish are found in the Bear River, indicating the water quality has declined and conditions for desirable coldwater sport fish are far from optimal.

There are very large areas of prime quality waterfowl habitat located within the Honeyville project boundaries. There are about 270,000 acres of marshland, most of which is excellent. The Bear River Refuge (65,000 acres) is in Box Elder County. A description of the refuge occurs in the Oneida Narrows discussion.

The net impact on the ecosystems of Honeyville is negligible. This impact results from the balancing of the positive and negative changes that would be expected from the development of the Honeyville site. This measurement of impact on the ecosystems is supported by the negligible changes predicted by a more quantitative evaluation made for the population and community components of the ecosystem. These components are more sensitive to change than the whole system.

Step 5. Report Information in EES Summary

A summary of the "with" and "without" evaluations and the number and distribution of the "red flags" is given in Table 22.

The net environmental impact from the development of Honeyville as measured by the ecology category was adverse but minor. The negative impact was caused by the loss of the habitat for the free floating organisms. It was expected that a beneficial improvement in the environment would result from the regulation of the inflow into the Bear River Waterfowl Refuge. However, because the quality of waterfowl in the area was already at its maximum, as measured by the EES, regulation of the flow could only improve the already "good" state a small amount. The EES was not sensitive to this small change.

In the environmental pollution category, the small adverse impact results from the balance of adverse and beneficial changes. The major improvements are similar to those discussed for Oneida Narrows, namely a reduction in streamflow variation and the decrease in turbidity. These improvements are offset by the increase in BOD

TABLE 22. EES SUMMARY: HONEYVILLE

SECTION I: VALUE OF IMPACT IN EIU

Category	Quantitative Change			Qualitative Change, Estimate	Net Change
	With Project	Without Project	Difference		
Ecology	81	81	0	-6	-6
Environmental Pollution	203	204	-1	-3	-4
Esthetics	56	48	+8	0	+8
Human Interest	33	47	-14	-3	-17
Total	373	380	-7	-12	-19

SECTION II: NUMBER OF RED FLAGS: PROBLEM AREAS AND DATA NEEDS

Category	Component	Problem Areas		Data Needs
		Minor	Major	
Ecology	Species and Populations	1	0	1
	Habitats and Communities	0	1	5
Environmental Pollution	Water Pollution	0	1	1
	Air Pollution	0	0	7
	Land Pollution	1	0	0
	Noise Pollution	0	0	1
Esthetics	Land	0	0	0
	Air	0	0	0
	Water	1	0	0
	Biota	1	0	0
	Man-made Objects	0	0	0
	Composition	0	0	0
Human Interest	Educational/Scientific Packages	1	0	3
	Historical Packages	0	1	0
	Cultures	0	0	0
	Mood/Atmosphere	1	1	0
	Life Patterns	1	1	0
Total		7	5	18

in the reservoir and expected increase air pollution around the reservoir from an increase in population and development. This increase in population and development also caused a decrease in the quality of and use in the reservoir.

The esthetics in the Honeyville segment could improve with the addition of the reservoir. Significant esthetic improvements would be expected because of the increase in water surface area and the reduction in drawdown.

The impact on the social environment is again the major adverse impact from the project development. In the Honeyville segment the main impact is from the loss of Hampton's Ford. Other less significant adverse impacts are from the disruption to the communities in the area and the expected loss of archeological information.

The "red flags" listed in the second section of the Summary table correspond to the adverse impacts discussed above. They have all been discussed in the preceding pages.

RESULTS OF FIELD TEST

Upon completion of the field test it was desirable to assess systematically how well the EES worked and, based upon experience gained in conducting the Oneida Narrows and Honeyville evaluations, how its use could have been improved. To assist in this assessment, Battelle-Columbus developed in the very early stages of the field test several evaluation criteria. These criteria were then employed after completion of the field test to assess the overall merits of the EES. Battelle-Columbus believes that these criteria are sufficiently comprehensive to assess the merits of any environmental impact methodology. The criteria are designed to indicate whether the framework for the analysis is meaningful, the use of the methodology is acceptable, and its output complete and unbiased.

Criteria for Evaluation of an Environmental Impact Methodology

Criteria used in the evaluation of environmental methodology are grouped into three areas of major concern:

- Form of the methodology
- Use of the methodology
- Output of the methodology.

Form of the Methodology

An environmental methodology must possess a number of specific elements to be usable in an environmental evaluation. It should

- Include the elements of ecology, environmental pollution, esthetics, and human interest as part of the system with each area being defined by a comprehensive list of parameters.
- Include consistency in form between evaluations. It is not desirable to permit the parameters or their importance to vary between projects.
- Include both spatial and temporal considerations. Areas such as upstream, site, transfer, and downstream, along with time horizons, such as construction and operation, are important.

- Include weights for indicators of environmental impacts.
- Include flexibility to handle data limitations.

Use of System

The methodology developed for the environmental impact assessment must be used in a way to detect all significant impacts. To aid in achieving this objective, the methodology should be used

- By an interdisciplinary team to produce "team" evaluations and not individual evaluations.
- To evaluate the project area more than once; a series of trips of moderate length is desirable.
- In a systematic way; results of the analysis should be replicable.

Output of the System

Output of the analysis is the most important consideration of the methodology. The results should

- Indicate trade-offs of beneficial and adverse environmental impacts
- Signal warnings of environmental sensitive areas
- Inform analysts and decision makers of data gaps in the area

Use of the Criteria to Assess the Battelle-Columbus Environmental Evaluation System

The criteria established for evaluation of an environmental impact methodology were formulated by Battelle-Columbus in the early stages of the EES development. In this way the criteria became part of the development process. Consequently the EES conforms very closely to the established criteria, although improvements are desirable in several areas.

Form of the EES

The EES parameters in the four main categories of ecology, environmental pollution, esthetics, and human interest were found to be sufficiently comprehensive to evaluate all environmental impacts associated with the Oneida and Honeyville segments. No environmental concerns were identified that could not be addressed within the context of one of the 78 parameters.

The evaluations of the Oneida and Honeyville segments were done by the same individuals in an identical fashion, using similar information and information sources, the same value functions, and the same relative weights for the parameters.

Spatial and temporal considerations were important in both the Oneida and Honeyville evaluations. In the Oneida evaluation, all possible dimensions of the spatial question – upstream, site, transfer, and downstream – were important, whereas in the case of Honeyville, all but transfer were important. The EES procedures for handling these considerations in a comprehensive and systematic fashion were found to be highly satisfactory.

Parameter Importance Units were found to be a satisfactory means of weighting the relative importance of various indicators of environmental impacts. In future uses of the EES, however, it would be desirable to have a more representative sample of society determine the distribution of PIU among parameters; the current distribution was determined by the five member research team.

Data limitations were found to be a problem in the Oneida and Honeyville evaluations. Problems stemmed from both the lack of data on well defined measurements and, in the case of ecosystems, a complete lack of knowledge within the discipline of how to measure this parameter. The flexibility inherent in EES worked very well in accommodating these limitations. Ecosystem information is handled in a purely descriptive fashion. Data needs are handled by a system of "red flags".

Use of the System

In conducting the evaluation of the Oneida and Honeyville segments, all members of the interdisciplinary research team interacted to produce "team" evaluations as opposed to individual evaluations. A field office was established at the Bureau office in Logan, Utah. The research team spent three uninterrupted weeks on-site conducting the evaluations. Because of the highly subjective nature of the esthetics and human interest evaluations, it was determined that it would have been desirable to include more than one individual on the research team to conduct evaluations in these categories.

To set the stage for the evaluations, a one-week reconnaissance trip was made to the area to get a feel for the situation and to identify potential information sources; this included a flight over the area in a light aircraft. Upon completion of the 3-week field effort, one individual of the research team revisited the area to fill data gaps that became apparent as the analysis of the evaluations proceeded.

The evaluations of the Oneida and Honeyville segments were conducted very systematically as a result of the procedures incorporated into the EES design. Evaluations in all four categories were conducted in the same basic fashion using the Parameter Importance Units and environmental quality ratings from the value functions to obtain "with" and "without" scores in Environmental Impact Units. Because of the way input data were organized with the aid of work sheets and the similarities in the ways in which data for all parameters were used, the results of the analysis are replicable.

Output of the System

The results of the Oneida and Honeyville evaluations provide clear insight into the possible trade-offs between beneficial and adverse environmental impacts. This is indicated primarily by whether the difference in Environmental Impact Units between the "with" and "without" evaluations is negative (adverse impact) or positive (beneficial impact).

The EES performed very well in indicating the environmentally sensitive areas in the Oneida and Honeyville segments. This was done through the system of "major" and "minor" red flags incorporated in the EES. In the judgment of the research team no environmentally sensitive areas failed to be keyed out by the "red flags" nor did a "red flag" appear in any area judged not be environmentally sensitive.

The EES performed satisfactorily in indicating data gaps to the research team and to potential decision makers. Data gaps are also handled by a system of "red flags". A summary table is provided for giving decision makers, and others who do not have time to read the text of the evaluations an overview of these problems.

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Utah State Water Resources Department, Salt Lake City, Utah
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Wyoming State Game and Fish Department, Cheyenne, Wyoming
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